Logistics Management Institute

DoD Educational Intervention Programs for Scientists and Engineers

FP002MR1

Dayton S. Pickett
David A. Smith

LMI

October 1995

DoD Educational Intervention Programs for Scientists and Engineers

FP002MR1

Dayton S. Pickett
David A. Smith

Prepared pursuant to Department of Defense Contract MDA903-90-C-0006. The views expressed here are those of the Logistics Management Institute at the time of issue but not necessarily those of the Department of Defense.

Logistics Management Institute
2000 Corporate Ridge
McLean, Virginia 22102-7805

Executive Summary

The Defense Department has a critical need for quality scientist and engineer personnel. Within the Department there is some concern that it may be more difficult in the future to attract and retain the quality and numbers needed. This study examines the fundamental issues related to understanding how best to deal with these challenges.

The Military Services and the Defense Agencies conduct or sponsor a rich profusion of programs that, taken together, act to improve the quantity and quality of professional scientists and engineers in the United States. The programs, over 130 in number, are typically aimed at one of several stages along the educational path: precollege, undergraduate, graduate, or postdoctoral/faculty. These educational programs have developed and multiplied over some five decades, and they have evolved with varying degrees of independence. Some of the programs are highly productive and should be expanded or copied. Others merit consolidation with similar, ongoing programs.

Based on our survey and analysis of these programs, we believe that these programs and activities should operate under the oversight of a central authority that provides constructive, sensitive guidance to this large group of programs. Specifically, we recommend five complementary actions:

- The Office of the Secretary of Defense (OSD) should develop a broad, DoD-wide set of goals and objectives for programs and activities of this kind. These goals and objectives will become the basis for guidance published by OSD for the Military Services and Defense Agencies. The guidance should help form individual program objectives, program emphases, and program boundaries.

This important management step should be taken in the interest of efficiency and accountability. Only in this way can the efforts of DoD as a Federal department be orchestrated properly with complementary enterprises conducted elsewhere in Government or in the private sector.

- The intervention programs of DoD should, where feasible, develop the characteristics prominent in the most successful of the present programs.

  - Precollege programs work best when they combine real work and challenging study. Examples are apprenticeships or similar efforts that

are complete with year-round mentors. Mentors may be employees of DoD or teachers from the participants' schools. Successful precollege programs avoid remedial academic work, overly restrictive participation rules, and simple "exposure" to S&E work like tours and visits.

- ► Undergraduate programs produce the best results when they are related directly to the world of S&E employment in DoD. Examples are the cooperative education arrangements with their work-study cycles; vacation-employment-with-promise-of-future-career-offer; and DoD employee programs that support periodic returns to the university for further study.

- ► The best graduate programs resemble good undergraduate programs in their direct relationship to current and future employment with DoD, but many good graduate programs also spawn research relationships and research products of interest to the sponsoring organization.

- ► Postdoctoral and faculty programs of high quality deliver research products attractive to DoD, but these programs are also oriented often toward DoD staff recruiting. The recruiting effort may be directed toward the support recipient, or it may be directed toward graduate students accompanying the researcher. Participation by promising graduate students along with postdoctoral or faculty researchers is another mark of program excellence.

- ◆ OSD should cause program managers to review and recast objectives of all programs. Attainment of the objectives should be measurable against reasonable standards applied by outside reviewers.

The effectiveness of even the best of the present programs cannot be measured with confidence because program objectives lack concreteness and specificity.

- ◆ The Director of Defense Research and Engineering should explore ways to establish DoD intervention programs aimed at the gaps and other transition points[1] along the S&E educational pipeline. When appropriate ways are found, OSD should provide resources to support new or altered programs aimed at these new targets.

Attrition of able students from the group of potential scientists and engineers is quite high at these gaps and other transition points in the educational process. No DoD programs now address this problem specifically. We believe the return, in increased numbers of students pursuing S&E curricula, could be quite high for such an investment.

---

[1] Gaps and other transition points are generally the times between consecutive phases in the educational process. They are usually accompanied by student vacations and movement from one type of school to another.

- The Defense Science Board and other organizations in which DoD officials and university or educational association leaders participate together should be asked to examine and to probe the high attrition of college freshmen and sophomores as a result of preparatory or screening courses for the sciences, mathematics, or engineering. This examination should be conducted with the objective of ultimately salvaging a measurable number of students of merit now being screened out.

While the lower division undergraduate years are neither a "gap" nor a "transition point" in the education process, this important period in students' lives witnesses the loss of many able students who have already declared their intention to embark on S&E academic majors. We lose more than we should.

* * * * *

These recommendations, if followed, will lead to increased integration among and accountability within these intervention efforts, which even now affect the lives of many young people in important ways.

Contents

Contents (Continued)

Contents (Continued)

Illustrations

Illustrations (Continued)

Illustrations (Continued)

Tables

CHAPTER 1

Introduction

BACKGROUND

Throughout the United States today there is widespread concern over the supply of scientists and engineers to meet the nation's future needs. This concern may be expressed in three general areas: (1) overall U.S. technological superiority, (2) national defense needs, and (3) replacement of senior scientists and engineers as those educated after World War II begin to retire.

The United States has long based part of its national defense strategy on an abundant supply of superior technology. A skilled and technologically sophisticated work force is required to develop, maintain, and utilize such advanced technology. Today, however, there are concerns about the current state of scientific and technical education and about demographic changes in the work force that may restrict the nation's ability to accomplish these objectives in future years:

- The United States is steadily losing much of its competitive technological advantage to other nations as they assume increasing economic importance based on well-educated and less expensive work forces.

- The U.S. population continues to age, with accompanying retirements among DoD scientists and engineers. College and university faculty attrition causes special concern. The National Science Foundation has projected a national shortage of over 500,000 scientists and engineers by the year 2010.

- In the dwindling pool of competent young students and workers, there are growing proportions of women and members of underrepresented minorities groups which traditionally have produced few scientists and engineers.

- Educational programs that produce scientists and engineers are graduating increasing numbers of international students who, should they elect to apply for DoD employment, frequently have some difficulty meeting national security clearance standards.

- The nation's families and schools are producing youths who are not competing as successfully as in the past with peers from other countries, as measured by standardized tests.

United States technological superiority is believed by some to depend on continued production of world-class scientists and engineers working at the cutting edge of technology. In the past, this condition has been measured in part by our numbers of Nobel laureates, patent awards, and by general understandings of our international strengths in space, chemicals, computer science, physics, astronomy, health care, and in several other fields. Some observers believe we cannot maintain these competitive positions in the face of the factors cited above. One penalty, of course, is the projected erosion of our economy and the nation's standard of living.

In the National Defense arena, we have consistently tried to develop and deploy superior, high-technology weapon systems that allow us to defend the United States with smaller armed forces than those possessed by our potential adversaries. With our value for human life, "high tech" weapons allow us to project an imposing, potent military force without exposing large numbers of U.S. military personnel to high risk. If the overall national ability to remain at the forefront of technology is impaired, we will not be able to maintain this technological edge with our weapons systems. The result will be life in a more dangerous world and the possible exposure of the United States to increased terrorism, localized conflicts, and miscalculations by adversaries resulting in high-damage wars.

Our colleges and universities have produced a steady stream of highly qualified scientists and engineers, especially since World War II. This has been made possible by a national, world-class faculty. Within the next 10 years, large numbers of these faculty members will approach the end of their productive careers. Many will retire. Those men and women will require replacement.

THE STUDY OF DOD SCIENTISTS AND ENGINEERS

Two DoD offices requested that the Logistics Management Institute (LMI) examine the national supply and the DoD demand for scientists and engineers over the next 20 years.[1] These sponsors are the Office of the Assistant Secretary of Defense for Force Management and Personnel [OSD(FM&P)] and the Office of the Director of Defense Research and Engineering (ODDR&E).[2] The first of these offices is responsible for establishing policies that recruit, train, retain, and separate the civilian and military personnel employed by the DoD. The second

[1] Not everyone agrees on just who comprises the nation's population of scientists and engineers. For this task, the OSD sponsors supplied a list of some 100 job titles in the form of Office of Personnel Management (OPM) job codes. That list was changed somewhat as this present work developed. In the course of the study, we noted that OPM and the National Science Foundation routinely use different job taxonomies to define their own "scientists and engineers" groups. A comparative listing of these several taxonomies is included in Annex E-3 to Appendix E.

[2] The Office of the Director of Defense Research and Engineering (ODDR&E) is a separate staff office in the Office of the Secretary of Defense. It is responsible for policy related to all DoD research and development activities and also for the management of S&E educational programs and activities.

office is responsible for developing new technologies and the resulting weapon systems used by our armed forces. Both have a vital interest in the ability of DoD to attract and retain adequate numbers of qualified scientists and engineers.

To further the Department's ability to attract and retain the best scientists and engineers, two fundamental issues needed to be examined. Therefore, this study was designed to address two objectives:

- To evaluate DoD's science and engineering intervention programs and
- To assess the national supply projections of scientists and engineers and the DoD demand for scientists and engineers to the year 2010.

The adequacy of the national supply of scientists and engineers depends partly, of course, on DoD's future requirements for scientific and engineering skills. Success in DoD's intervention programs means an increase in the national supply of scientists and engineers and encouragement of growing numbers of high-quality scientists and engineers to pursue their careers within DoD.

DoD Scientist and Engineering Intervention Programs

The Military Services and Defense Agencies have developed a range of programs that focus on increasing the numbers or quality of scientists or engineers within the United States, and more especially within the DoD work force. These programs use a variety of techniques for motivating or educating prospective personnel. These techniques include: increasing students' understanding and interest in careers in science and engineering; identifying professional or teaching mentors to work with and relate to; providing work experiences that relate to science and engineering tasks; providing income to assist students to remain in or to enroll in schools, colleges, or universities so that they may pursue science and engineering curricula; awarding scholarships, assistantships, or fellowships to encourage continued study in science and engineering fields; and providing research opportunities for science and engineering professionals to enhance their experience and provide increased knowledge to pass on to other students.

Some of these programs also have secondary purposes: stimulating interest in science and engineering; increasing employment of scientists and engineers within DoD; career development of current employees; encouraging or supporting research in areas of DoD interest; recruiting scientist and engineering personnel into sponsoring agencies and organizations; and targeting certain subpopulations such as members of underrepresented minorities, women, handicapped people, and junior faculty members for special encouragement and support.

DoD Scientist and Engineer Supply and Demand

This part of the study was intended to provide DoD with a model to express the supply of scientist and engineering personnel that would be available to meet DoD scientist and engineering needs while also representing DoD demand for scientist and engineering personnel through the year 2010. Early on in the study design, it was determined by the sponsors that the second objective should focus on an examination of the supply of scientists and engineers. Work on the demand for scientist and engineer personnel through the year 2010 was deferred for a later project.

The Report

This report focuses on the first objective of the study, an evaluation of DoD science and engineering intervention programs. In addition, some portion of the scientist and engineer supply and demand problem is examined as a baseline for work intended as part of the second phase of the study. It has been useful to make preliminary analyses of the supply and demand problem to understand the utility and application of the intervention programs with greater clarity.

In Chapter 2, we provide a summary of major trends that effect the future supply of scientists and engineers in the United States. Since all of the people who will serve as scientists or engineers in the year 2010 have already been born, examination of the characteristics and trends in the current population will provide some insight into the size and scope of the supply "problem."

Chapter 3 describes the science and engineering pipeline, from preschool student interest through postdoctoral research, and Chapter 4 provides a comprehensive description of the intervention programs identified thus far in DoD.

In Chapter 5, we present the results of our review, identifying the most important of many program characteristics. We include both positive traits that characterize programs that work and questionable traits that mark programs that could be improved or restructured. The end of the chapter provides a brief summary of the best programs of the sample chosen.

Chapter 6 contains conclusions and recommendations to this study.

A number of important appendices accompany this report. They contain information that augments and supports the information presented in the main body of the report. Appendix A contains a master list of the 136 educational intervention programs identified by DoD in 1990 in response to Congressional inquiry. Appendix B includes complete descriptions of the 32 intervention programs we selected for detailed evaluation. Appendix C contains tables supporting many data and figures found in the text. Appendix D includes citations and brief descriptions of all statutory or legal authorities under which

scientific and engineering employees civilian and military employed by DoD since 1980, by general field of expertise (the 1990 data have a more detailed format). Appendix F displays comparative data on the longevity of newly hired scientists and engineers at one of the installations visited. Appendix G contains the March 1990 report on education activities submitted by DoD to Congress. Finally, Appendix H describes the objectives for the intervention programs.

CHAPTER 2

Trends Affecting the National Supply of Scientists and Engineers

INTRODUCTION

The supply of scientists and engineers important to the defense of the United States is part of a complex process. In this chapter, we approach a review of that process by first citing the concerns now being expressed within the Department of Defense and then by providing an overview of the overall population trends, identified by racial and ethnic subgroup. A special look at the demographics of America's youth follows.

Because scientists and engineers are produced by the colleges and universities of the United States, we then review in detail the nation's college enrollments followed by an even closer examination of our universities' degree production in S&E disciplines, at both the baccalaureate and doctorate levels. This college and university section makes up more than half the entire chapter.

We then move to a more youthful population, America's high school students, because it is they who become the college enrollees we have reviewed in such detail. The final section of this part of the chapter reviews historical trends in career preferences of those who have just graduated from the nation's high schools.

The chapter closes with a brief discussion of just what bearing all these trends might have on the future supply of our population of S&E professionals.

DoD CONCERNS

An important factor in the national defense strategy of the United States throughout much of its recent history is an abundant supply of superior technology helping to offset potential adversaries' numerical advantages. A skilled and technologically sophisticated work force is required to develop, maintain, and utilize that superior technology fully. Unfortunately, a number of concerns about the current state of scientific and technical education and about impending demographic changes in this important work force have brought into question the ability of the Department of Defense (DoD) to carry out its mission completely and responsively in future years.

According to the latest available National Science Foundation (NSF) estimate,[1] there were 5,474,600 scientists and engineers in the U.S. work force in 1988. Approximately 137,000 civilian employees and 62,000 military members in DoD are scientists and engineers,[2] or about 3.6 percent of the nation's total pool. It is estimated that DoD also does business with another 600,000 (or 11 percent) of the nation's scientists and engineers, most of whom are employed in defense-related industries. While not overpowering, then, the DoD share (600,000 + 199,000 = 799,000 or 14.6 percent of the national pool) of U.S. scientists and engineers is not a trivial one.[3] It is likely, of course, that the size of this defense-related S&E work force will be reduced somewhat over the next decade or so due to reduced international tensions and the resulting shrinkage of our defense forces and activities.

One senior DoD official has recently identified several issues with potentially serious implications for the nation's future defense posture:

- A projected shortfall of over 500,000 scientists and engineers by the year 2010
- A projected shift in demographics away from the groups which have provided the largest numbers of scientists and engineers in the past
- Unfavorable performance by U.S. high school students in science and math tests relative to other industrialized nations
- A decline in the numbers of U.S. students pursuing S&E careers
- Continued deterioration of pay and benefits of federal scientists and engineers relative to private industry and academia.[4]

This is not an isolated concern. DoD needs to know whether the future production of scientists and engineers will decrease significantly. If so, will the decrease be great enough to affect national security? This chapter describes present trends that will affect the supply of scientists and engineers for the next 20 years. The data presented below address many of the above concerns and provide a baseline of scientist and engineer supply data used throughout the remainder of this report.

---

[1] National Science Foundation. *U.S. Scientists and Engineers: 1988 — Detailed Statistical Tables*. Washington, D.C.: Surveys of Science Resources Series (NSF88-322), undated, p. 6.

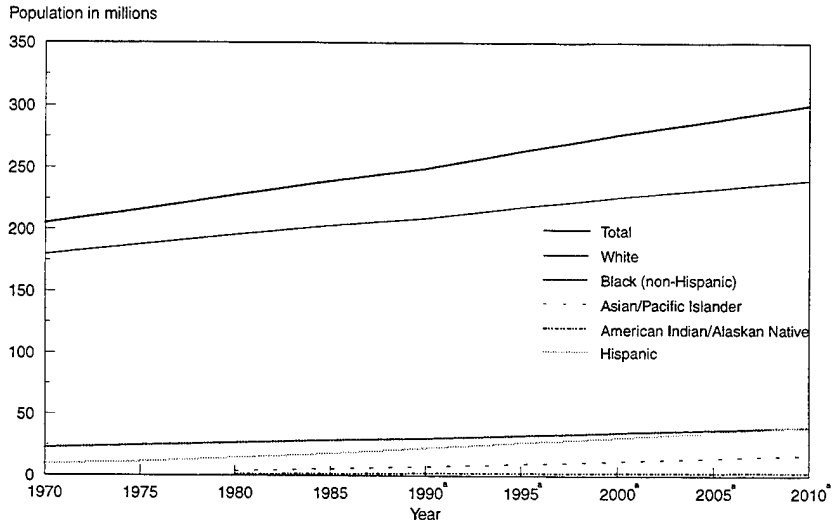
[2] Defense Manpower Data Center. October 1990. See Appendix E.

[3] There are about 100 separate job titles in DoD's scientific and engineering work force. For the specialists educated in several of the more arcane fields, DoD-related employment may well represent the preponderance of professional opportunities anywhere. Appendix E contains a list of all Department of Defense jobs classified as scientific and engineering (S&E).

[4] Testimony of Dr. Ted Berlincourt, Director, Research and Laboratory Management, DoD, to the Subcommittee on Defense Industry and Technology of the Committee on Armed Services, U.S. Senate, May 7, 1990.

DEMOGRAPHIC TRENDS

The population of the U.S. is expected to reach 300.4 million by the year 2010, as estimated by the Bureau of the Census. This projection and selected subsets of the national population are reflected in Figure 2-1 for the years 1970 through 2010. See Table C-1, Appendix C for supporting data.[5]



Source: *Historic (1970 – 1985):* Miller, Louisa and Jennifer Marks. *Preliminary Estimates of the Population of the United States, by Age,Sex, and Race: 1970 to 1981.* Washington, D.C.: U.S. Bureau of the Census, Current Population Reports, Population Estimates and Projections (Series P-25, No. 917), July 1982, pp. 9, 10, 17, 18, 24, and 25; Hollmann, Frederick W. *United States Population Estimates, by Age, Sex, Race, and Hispanic Origin: 1980 to 1988.* Washington, D.C.: U.S. Bureau of the Census, Current Population Reports, Population Estimates and Projections (Series P-25, No. 1045), January 1990, pp. 7 and 11, and; Hollmann, Frederick W. *United States Population Estimates, by Age, Sex, Race, and Hispanic Origin: 1989.* Washington, D.C.: U.S. Bureau of the Census, Current Population Reports, Population Estimates and Projections (Series P-25, No. 1057), March 1990, pp. 3 and 7.

Estimated and Projected (1990 – 2010): Day, Jennifer Cheesemen. *Population Projections of the United, by Age, Sex, Race, and Hispanic Origin: 1993 to 2050,* Washington, D.C.: U.S. Bureau of the Census. Current Population Reports (Series P-25, No. 1104), November 1993, pp. xvi, xxii..

Note: Persons of Hispanic origin may be of any race. See Table C-1, Appendix C, for supporting data.

[a] Middle Series projections.

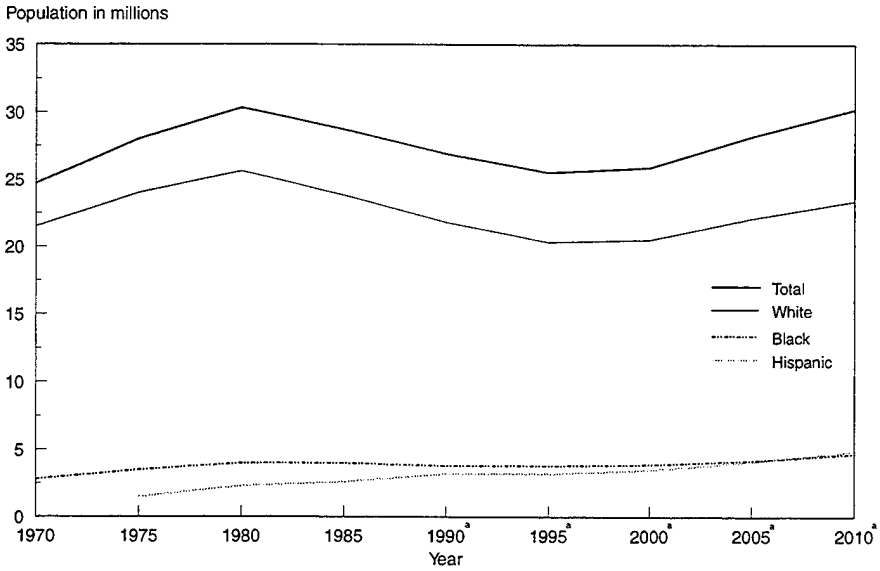
Figure 2-1.
United States Demographics (by race and ethnic group)

There are striking contrasts among the racial and ethnic groups. While the total population is increasing (from 1990 to 2010) by over 20 percent (or 51 million people), the black subpopulation is growing at more than one and a half times that rate (31.4 percent). The Hispanic subpopulation, meanwhile, is increasing nearly four times as fast (79.2 percent), and now constitutes the fastest-growing subset of the U.S. population, proportionately.

What about the youth of the nation? Figure 2-2 displays the growth occurring among the white, black and Hispanic subpopulations of young people of ages 18 to 24. The black population of youth shows a modest dip in the 1990s,

[5] Appendix C contains tabular data supporting all figures in this chapter.

followed by increased growth. Hispanics experience no such dip in population; they maintain continued and significant growth throughout the period. The white youth subpopulation, however, reflects a significant dip in numbers in the 1990s; they recover only a portion of that loss in later years.



Source: Historic (1970 – 1985): Miller (Series P-25, No. 917), pp. 9, 10, 17, 18, 24, and 25; Hollmann (Series P-25, No. 1045), pp. 7 and 11; and Hollmann (Series P-25, No. 1057), pp. 3 and 7.
Estimated and Projected (1990 – 2010): Day, Jennifer Cheesemen. *Population Projections of the United, by Age, Sex, Race, and Hispanic Origin: 1993 to 2050*, Washington, D.C.: U.S. Bureau of the Census. Current Population Reports (Series P-25, No. 1104), November 1993, pp. xxv xxvi.

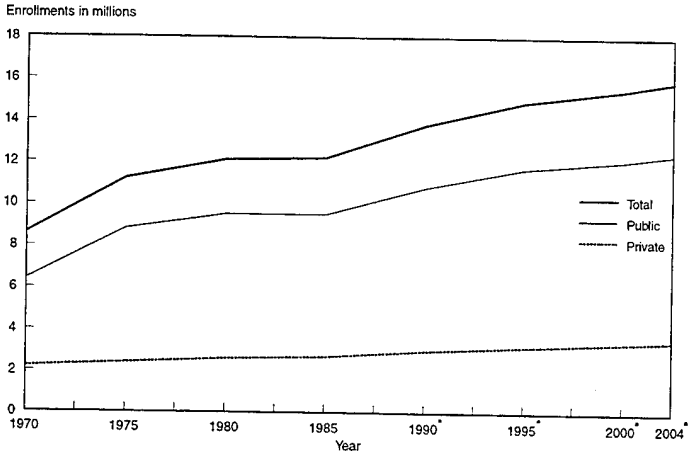
Note: Persons of Hispanic origin may be of any race. See Table C-1, Appendix C, for supporting data.

[a] Middle Series projections.

Figure 2-2.
United States Youth Demographics (ages 18 to 24)

College Enrollments

Enrollments in institutions of higher education have continued to rise since 1970. Between 1970 and 1980, the growth of enrollments (all ages) was significant, amounting to 3.5 million persons or nearly 41 percent of total enrollments at the of the period. From 1980 to 1990 the growth is smaller (1.7 million or 14.1 percent). During the decade 1990 to 2000, total enrollments are projected to increase by 1.7 million students (12.3 percent of the 1990 enrollment population) to a total of 15.5 million people. These enrollments are shown in Figure 2-3.



Source: *Historic (1970 – 1990):* Snyder, Thomas D., Project Director. Digest of Education Statistics, 1993. Washington, D.C.: U.S. Department of Education, National Center for Education Statistics (NCES 93-292), October 1993, p. 175.

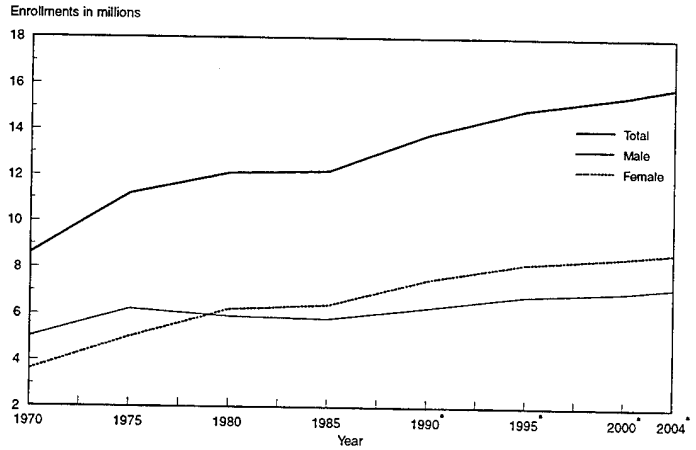
Projected (1990 – 2004): Gerald, Debra E., et al. Projections of Education Statistics to 2004. Washington, D.C.: U.S. Department of Education, National Center for Education Statistics (NCES 93-256), September 1993, p. 26.

Note: See Table C-2, Appendix C, for supporting data.

[a] Middle alternative projections.

Figure 2-3.
Enrollments in U.S. Institutions of Higher Education (by type of school)

All groups within the college-enrolled population are increasing in size, although at different rates. Male enrollments will continue a slow increase, while the enrollment of females have been and will continue to be up significantly. By 1980, female enrollment at colleges and universities in the United States had begun to exceed male enrollments; female enrollment is projected to remain larger than that of males through the year 2004. These data are shown in Figure 2-4.



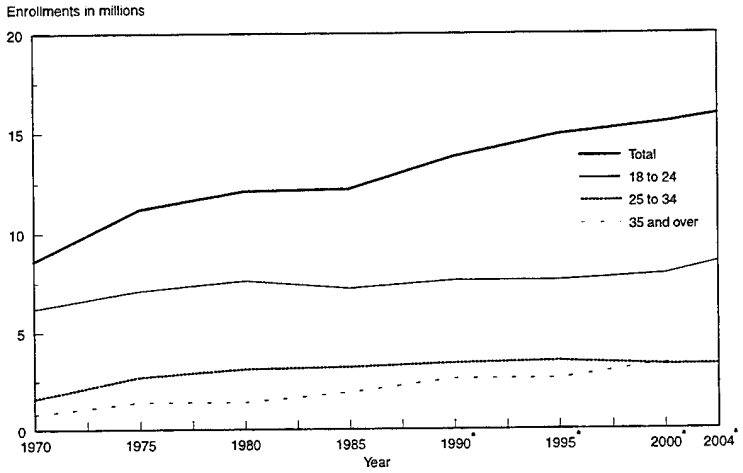
Source: Historic (1970 – 1990): Snyder, (NCES 93-292), p. 174. *Projected (1990 – 2004)*: Gerald, (NCES 93-256), p. 26.

Note: See Table C-2, Appendix C, for supporting data.

[a] Middle alternative projections.

Figure 2-4.
Enrollments in U.S. Institutions of Higher Education (by gender)

Although the total 18- to 24-year-old population in the year 2000 will be 1,000,000 smaller than it was in 1990 (Figure 2-2), the projected total college enrollment of 18- to 24-year-old students should continue to rise by 300,000 or by 3.9 percent during the same decade. This means, of course, that a larger portion of the 18- to 24-year-old age pool will be entering college than in the past. Earlier dramatic enrollment increases among older college students, aged 25 through 34, had ended by 1990. Enrollments of this group have declined slightly, while those of the 35-and-over age group continue to increase through the year 2000. Figure 2-5 displays this information.



Source: *Historic (1970 – 1990):* Snyder (NCES 93-292), p. 176.
Projected (1990 – 2004): Gerald (NCES 93-256), pp. 26, 29.
Note: See Table C-2, Appendix C, for supporting data.
[a] Middle alternative projections.

Figure 2-5.
Enrollments in U.S. Institutions of Higher Education (by age)

Table 2-1 shows that all racial and ethnic groups continue to reflect level or increased enrollments. The same observation holds for enrollments by academic level (see Figure 2-6). The continuing upward trend in overall enrollments is due principally to the continuing growth in female enrollments.

Table 2-1.
Total Enrollments in U.S. Institutions of Higher Education (by race and ethnic group)
(millions)

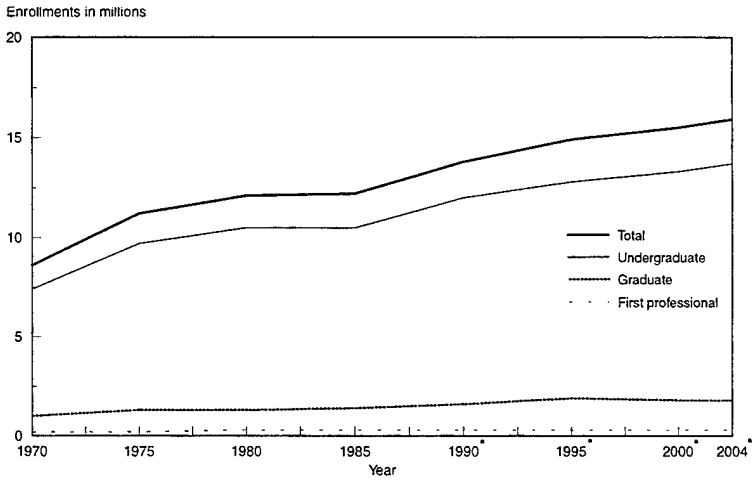
Race/ethnic group	1976[a]	1980	1985	1990	1991[b]
White, non-Hispanic	9.1	9.8	9.9	10.7	11.0
Black, non-Hispanic	1.0	1.1	1.1	1.2	1.3
Hispanic	0.4	0.5	0.6	0.8	0.9
Asian/Pacific Islander	0.2	0.3	0.4	0.6	0.6
American Indian/Alaskan Native	0.1	0.1	0.1	0.1	0.1
Nonresident aliens	0.2	0.3	0.3	0.4	0.4
Total	11.0	12.1	12.5	13.8	14.4[c]

Source: Snyder (NCES 89-643), p. 193.

Note: See Table C-2, Appendix C, for supporting data.

[a] First year data available.

[b] Preliminary data.



Source: *Historic (1970 – 1990):* Snyder (NCES 93-292), pp. 187 and 188. *Projected (1990 – 2004)*: Gerald (NCES 93-256), pp. 37 – 39.

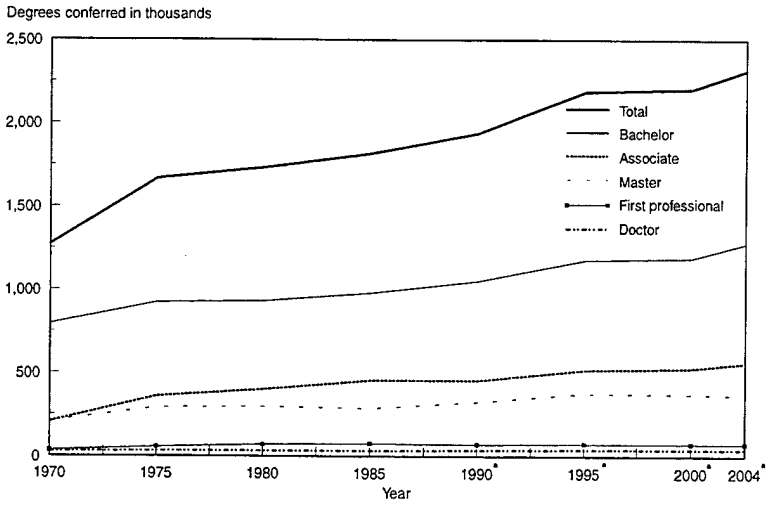
Note: See Table C-2, Appendix C, for supporting data.

[a] Middle alternative projections.

Figure 2-6.
Enrollments in U.S. Institutions of Higher Education (by academic level)

College Degrees Conferred

According to projections published by the National Center for Educational Statistics, the total number of degrees conferred annually by U.S. colleges and universities will continue to increase after 1990 (see Figure 2-7). These projections are generally consistent with the rising college enrollment populations just discussed.



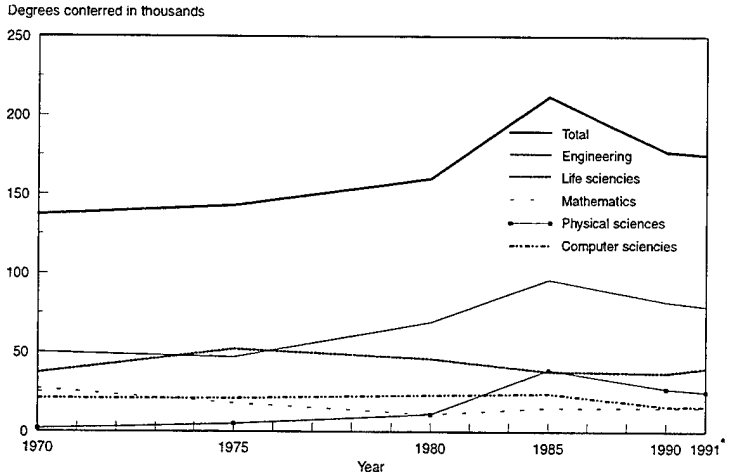
Source: *Historic (1970 – 1990):* Snyder (NCES 93-292), p. 243. *Projected (1995 – 2004)*: Gerald (NCES 93-256), p. 60 – 64.

Note: See Table C-3, Appendix C, for supporting data.

[a] Middle alternative projections.

Figure 2-7.
Total U.S. College Degrees Conferred Annually (by level)

Figure 2-8 shows the annual award of baccalaureate degrees by selected groups of degree fields. By 1985, degrees in life sciences had fallen off, while those in the physical sciences, computer science, and engineering were up (engineering and computer science were up significantly). Mathematics was down but may be rebounding. After 1985, total degrees conferred are generally down.



Source: Snyder (NCES 93-292), p. 256 – 263.

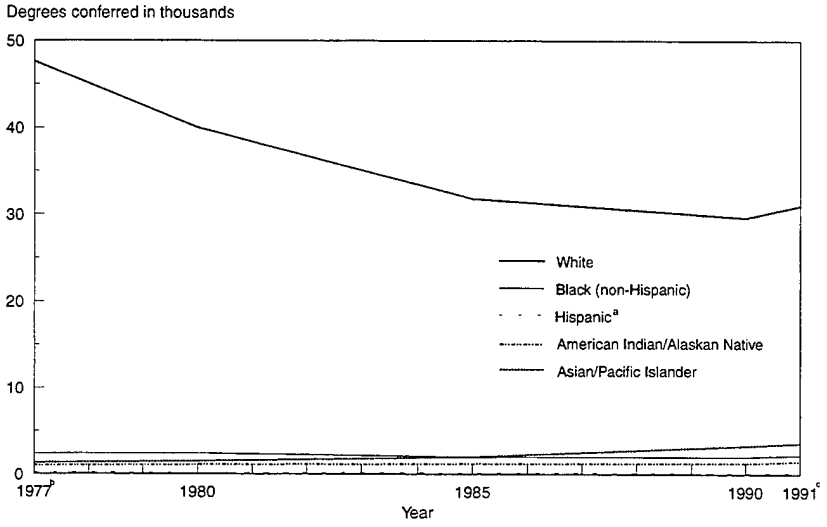
Note: See Table C-4, Appendix C, for supporting data.

[a] Preliminary data.

Figure 2-8.
Total U.S. College Degrees Conferred Annually (by broad, selected

More and more members of major ethnic and racial groups are receiving baccalaureate degrees in mathematics, computer science and engineering. Bachelor's degrees conferred annually in each broad scientific and engineering field by major ethnic and racial group are reflected in Figures 2-9 through 2-13. Although the numbers are small, the percentage increases in some minority groups are notable (see also Table C-5 in Appendix C).

In addition, some gains are being made by minority groups in the number of bachelors' degrees received if all scientific and engineering fields are considered together. As Figure 2-14 shows, there were 2,500 Hispanic recipients of S&E baccalaureates in 1977. By 1990, the number had increased to 5,600 (a growth of 124 percent over the 13 years considered). Similarly, the number of blacks receiving S&E baccalaureates was up by 3,400 or 61 percent for the same period, even when limited decreases in the life sciences are considered (see also Table C-5, Appendix C).



Source: (1977 – 1985): Baker, Curtis O., ed. Education Indicators: 1989. Washington, D.C.: U.S. Department of Education, National Center for Education Statistics (NCES 89-653), pp. 241-243; (1990 and 1991): Snyder (NCES 93-292), pp. 276 and 277.

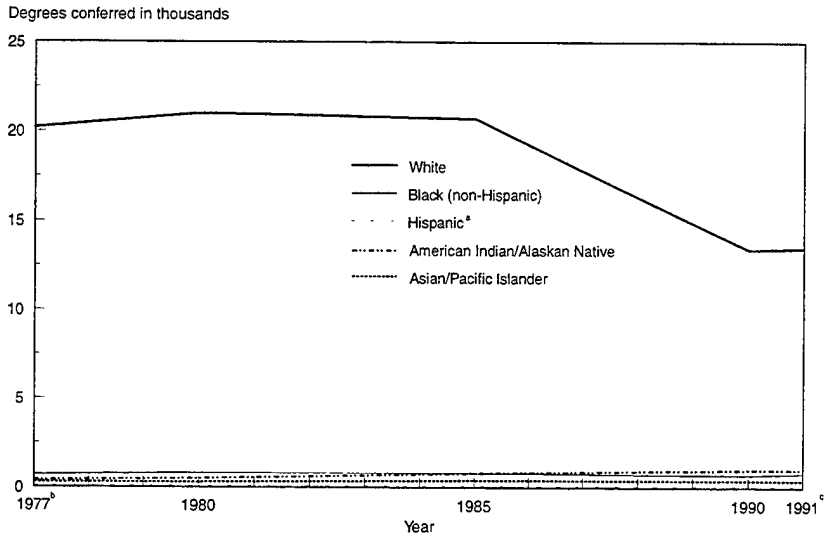
Note: See Table C-5 for supporting data.

[a] Persons of Hispanic origin may be of any race.

[b] Race/ethnicity data by field not available prior to 1977.

[c] Preliminary data.

Figure 2-9.
Total U.S. Bachelor's Degrees Conferred Annually in the Life Sciences



Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 241 – 243; *(1990 and 1991):* Snyder (NCES 93-292), pp. 276 and 277.

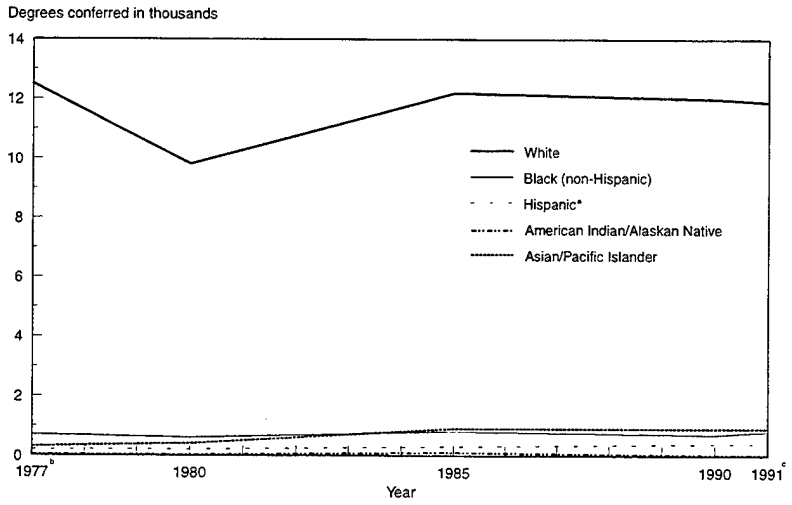
Note: See Table C-5 for supporting data.

[a] Persons of Hispanic origin may be of any race.

[b] Race/ethnicity data by field not available prior to 1977.

[c] Preliminary data.

Figure 2-10.
Total U.S. Bachelor's Degrees Conferred Annually in the Physical Sciences



Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 241 – 243; *(1990 and 1991):* Snyder (NCES 93-292), pp. 276 and 277.

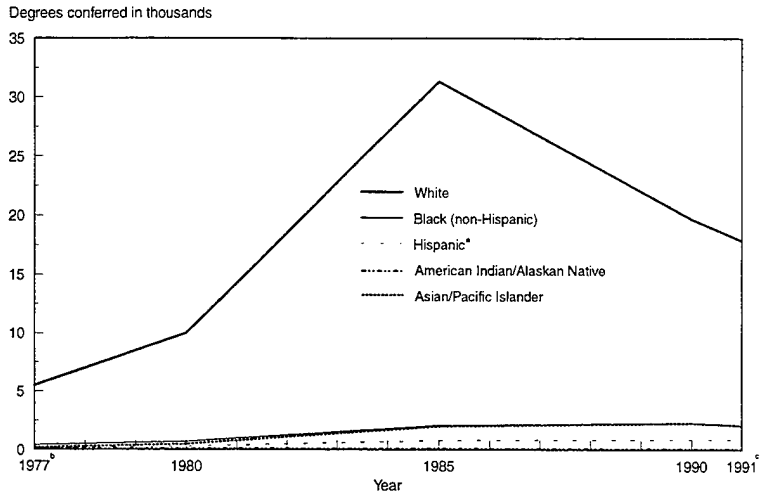
Note: See Table C-5 for supporting data.

[a] Persons of Hispanic origin may be of any race.

[b] Race/ethnicity data by field not available prior to 1977.

[c] Preliminary data.

Figure 2-11.
Total U.S. Bachelor's Degrees Conferred Annually in Mathematics (by race and ethnic group)



Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 241 – 243; *(1990 and 1991):* Snyder (NCES 93-292), pp. 276 and 277.

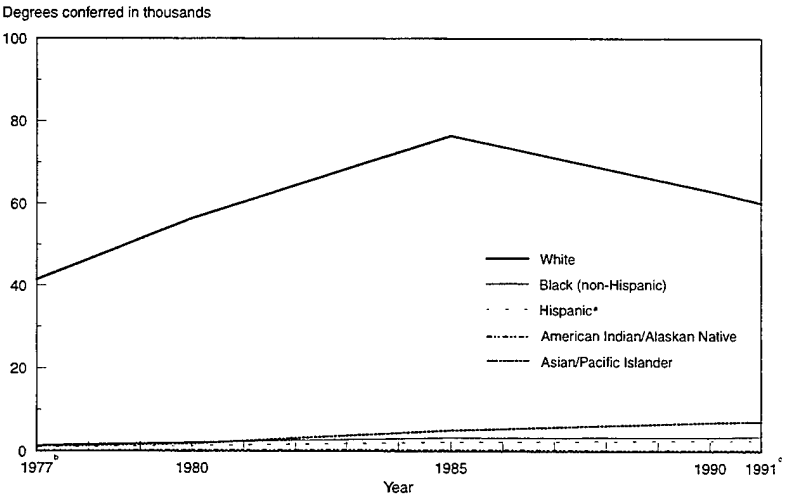
Note: See Table C-5 for supporting data.

[a] Persons of Hispanic origin may be of any race.

[b] Race/ethnicity data by field not available prior to 1977.

[c] Preliminary data.

Figure 2-12.
Total U.S. Bachelor's Degrees Conferred Annually in Computer Science (by race and ethnic group)



Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 241 – 243; *(1990 and 1991):* Snyder (NCES 93-292), pp. 276 and 277.

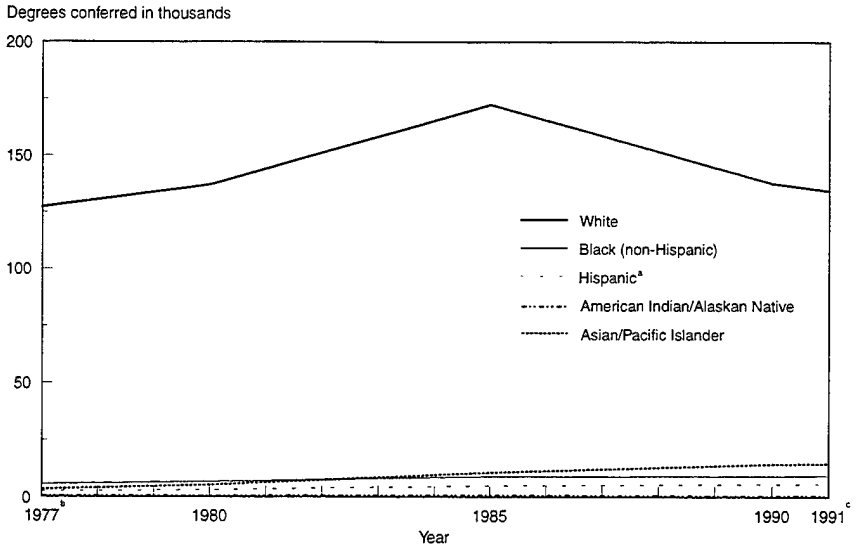
Note: See Table C-5 for supporting data.

[a] Persons of Hispanic origin may be of any race.

[b] Race/ethnicity data by field not available prior to 1977.

[c] Preliminary data.

Figure 2-13.
Total U.S. Bachelor's Degrees Conferred Annually in Engineering (by race and ethnic group)



Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 241 – 243; *(1990 and 1991):* Snyder (NCES 93-292), pp. 276 and 277.

Note: See Table C-5 for supporting data.

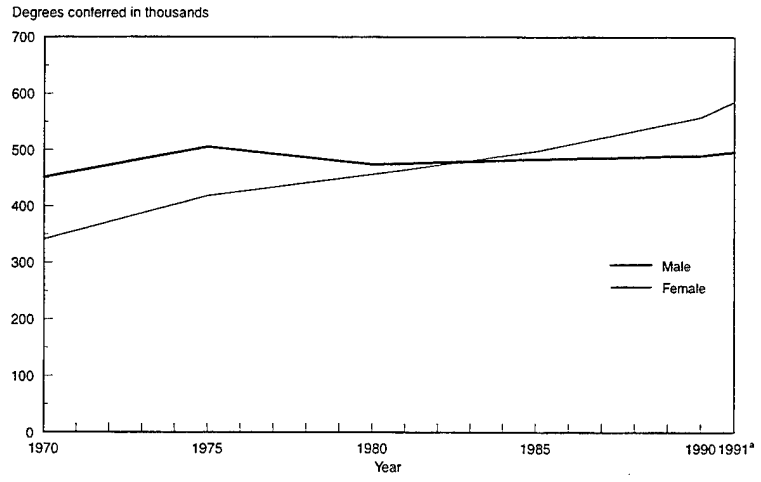
[a] Persons of Hispanic origin may be of any race.

[b] Race/ethnicity data by field not available prior to 1977.

[c] Preliminary data.

Figure 2-14.
Total U.S. Bachelor's Degrees Conferred Annually in All Scientific and Engineering Fields (by race and ethnic group)

Figure 2-15 shows all U.S. bachelor's degrees conferred annually, by gender. The steady growth in the number of female recipients is the most notable feature of this figure.



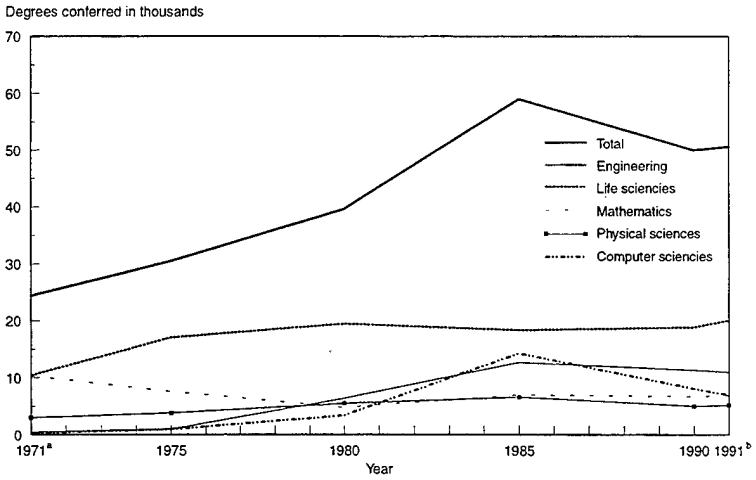
Sources: Snyder (NCES 93-292), pp. 243, 276, 277.

Note: See Table C-6, Appendix C, for supporting data.

[a] Preliminary data.

Figure 2-15.
Total U.S. Bachelor's Degrees Conferred Annually (by gender)

An examination of the distribution of degrees received by women in five groupings of the science and engineering fields reveals interesting trends. Figure 2-16 displays these data.



Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 241 – 243; *(1990 and 1991):* Snyder (NCES 93-292), pp. 276 and 277.

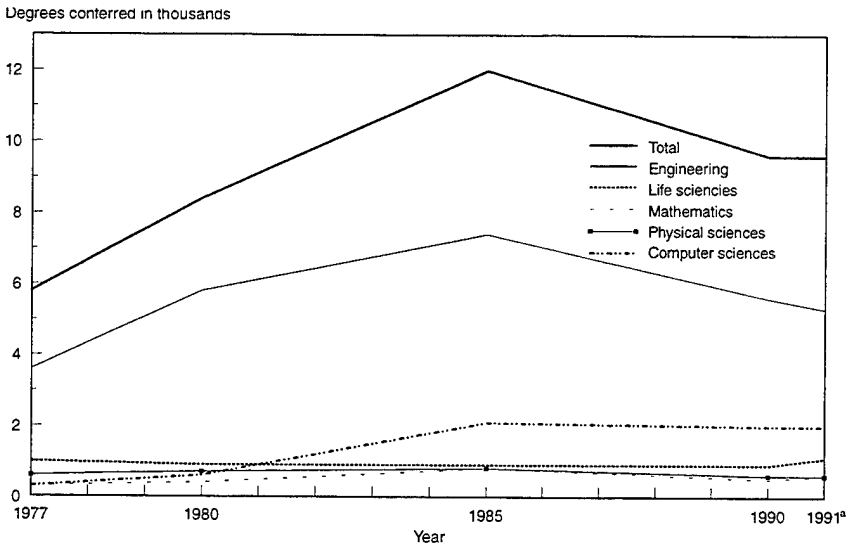
Note: See Table C-7, Appendix C, for supporting data.

[a] Preliminary data.

Figure 2-16.
Total U.S. Bachelor's Degrees Conferred Annually Upon Women (by broad, selected fields)

In the life sciences, the number of women receiving bachelor's degrees annually has been reasonably constant since the late 1970s. In the fields of the physical sciences, computer science, and engineering, the numbers of women receiving bachelor's degrees are up significantly over 1971, even considering recent declines. Baccalaureates in the physical sciences are up by 2,200 or 73 percent. Computer science is up by 7,100 from almost zero. The same observation holds for engineering: an increase of 10,600 from nearly zero in 1971. In mathematics, the overall trend is generally level since 1975. The numbers of women now receiving degrees in science and engineering are relatively large. They are starting to represent a sizable portion (approaching 30 percent) of all S&E degrees conferred.

A growing number of foreign students are receiving degrees in science and engineering in the United States. Increases are occurring both at the baccalaureate level and among those receiving doctorates. As shown in Figure 2-17, the number of foreign students who received S&E baccalaureate degrees in 1990 totaled fewer than 10,000 graduates, or just over 5 percent of the 177,000 S&E bachelor's degrees conferred, and fewer even than the 14,400 Asian/Pacific Islander U.S. citizen ethnic subgroup receiving S&E baccalaureates in 1990 (see Figure 2-14). Foreign nationals receiving S&E doctorates represent significantly higher percentages of the total number of degrees awarded. Figures 2-18 through 2-23 present these data.

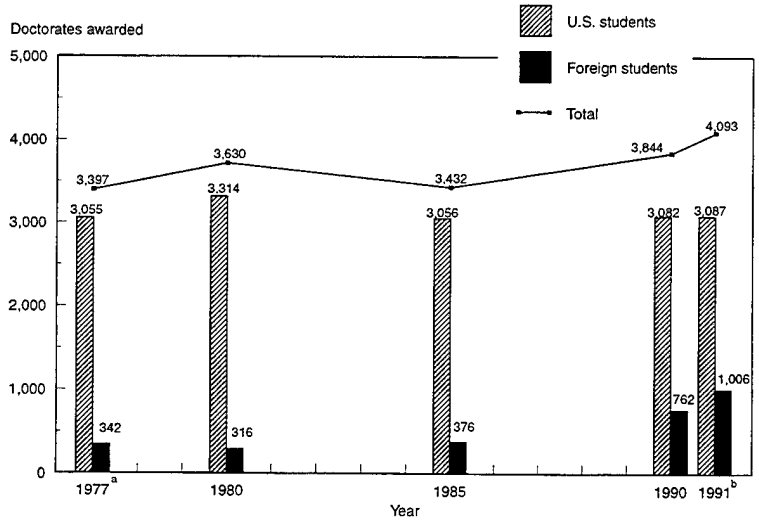


Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 243; *(1990 and 1991):* Snyder (NCES 93-292), pp. 276 and 277.

Note: See Table C-8, Appendix C, for supporting data.

[a] Preliminary data.

Figure 2-17.
Total U.S. Bachelor's Degrees Conferred Annually Upon Foreign Students (by broad, selected fields)

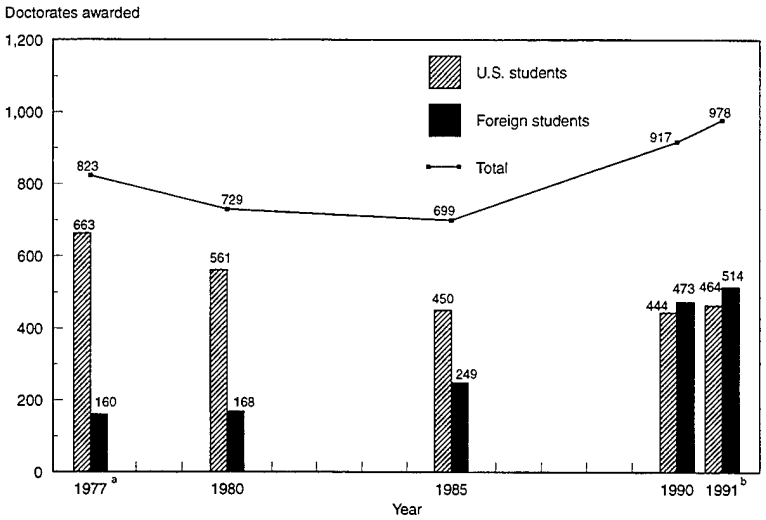


Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 225 and 249; *(1990 – 1991):* Snyder (NCES 93-292), pp. 282 and 283.

Note: See Table C-9, Appendix C, for supporting data.

[a] Preliminary data.

Figure 2-18.
U.S. Doctorates Awarded Annually in the Life Sciences (by citizenship)



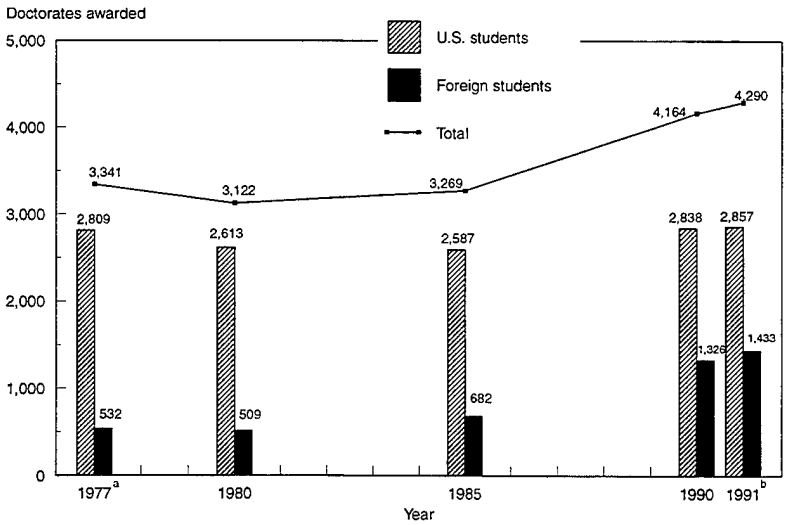
Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 225 and 249; *(1990 – 1991):* Snyder (NCES 93-292), pp. 282 and 283.

Note: See Table C-9, Appendix C, for supporting data.

[a] Foreign Student data by field first available in 1977.

[b] Preliminary data.

Figure 2-19.
U.S. Doctorates Awarded Annually in Mathematics (by citizenship)



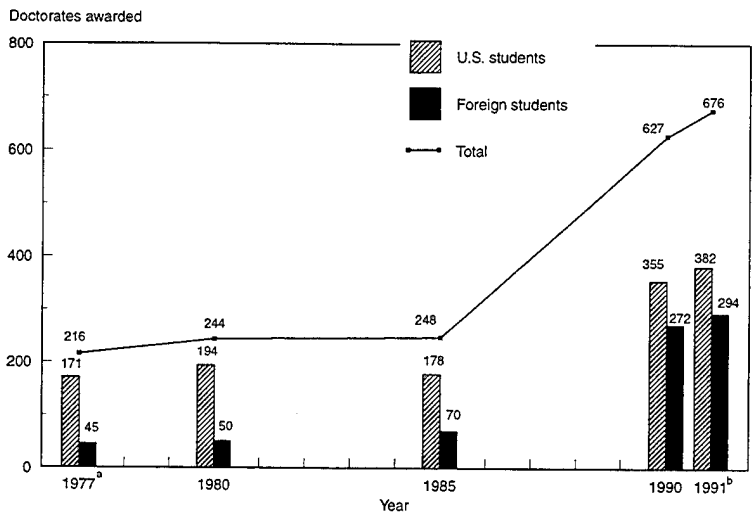
Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 225 and 249; *(1990 – 1991):* Snyder (NCES 93-292), pp. 282 and 283.

Note: See Table C-9, Appendix C, for supporting data.

[a] Foreign Student data by field first available in 1977.

[b] Preliminary data.

Figure 2-20.
U.S. Doctorates Awarded Annually in the Physical Sciences (by citizenship)



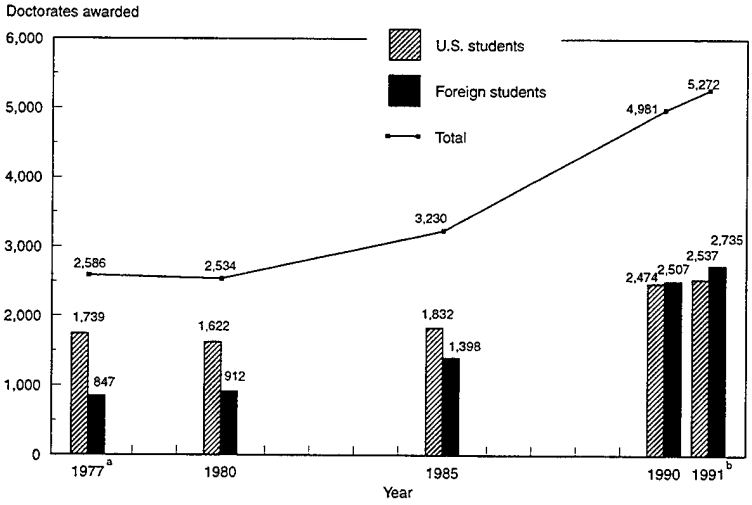
Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 225 and 249; *(1990 – 1991):* Snyder (NCES 93-292), pp. 282 and 283.

Note: See Table C-9, Appendix C, for supporting data.

[a] Foreign Student data by field first available in 1977.

[b] Preliminary data.

Figure 2-21.
U.S. Doctorates Awarded Annually in Computer Science (by citizenship)



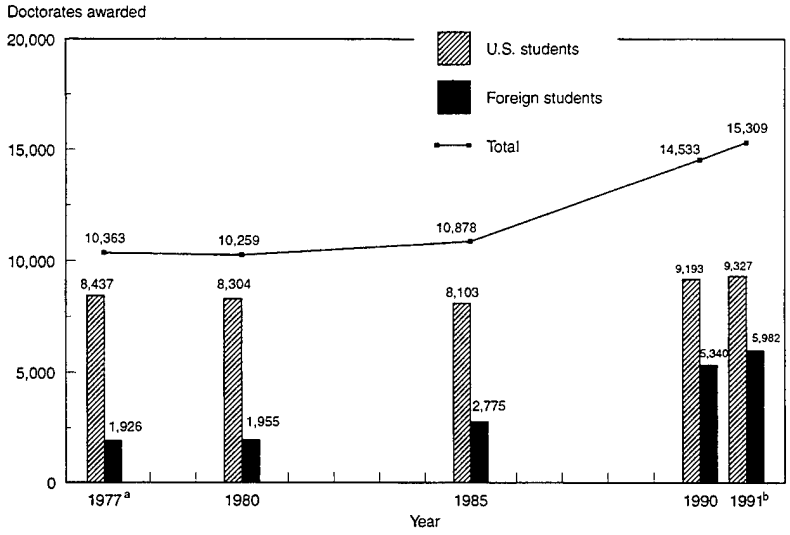
Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 225 and 249; *(1990 – 1991):* Snyder (NCES 93-292), pp. 282 and 283.

Note: See Table C-9, Appendix C, for supporting data.

[a] Foreign Student data by field first available in 1977.

[b] Preliminary data.

Figure 2-22.
U.S. Doctorates Awarded Annually in Engineering (by citizenship)



Sources: *(1977 – 1985):* Baker (NCES 89-653), pp. 225 and 249; *(1990 – 1991):* Snyder (NCES 93-292), pp. 282 and 283.

Note: See Table C-9, Appendix C, for supporting data.

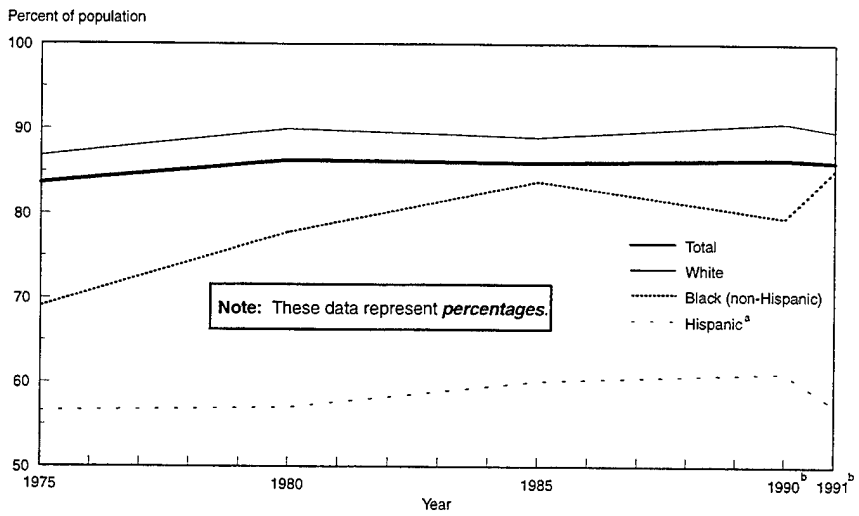
[a] Foreign Student data by field first available in 1977.

[b] Preliminary data.

Figure 2-23.
U.S. Doctorates Awarded Annually in All Science and Engineering Fields (by citizenship)

HIGH SCHOOL STUDENT CHARACTERISTICS

In considering those studying in S&E fields in the nation's colleges, it is instructive to review the pool of young Americans from which our undergraduate S&E student populations are drawn. Figure 2-24 shows the percentage of beginning high school students who go on to complete high school successfully by age 28 to 29. This higher-aged cutoff has been used because it represents final completion rates realistically. While the graduation rates of both blacks and Hispanics have grown between 1980 and 1990, the rate for whites has remained level. Recent preliminary indications reflect decreases for both whites and Hispanics. When measured against the baseline of 1975, however, the rates of all three groups are higher.



Sources: Alsalam, Nabeel, ed. *The Condition of Education: 1993.* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics (NCES 93-290), p. 253.

Note: See Table C-10, Appendix C, for supporting data.

[a] Persons of Hispanic origin may be of any race.

[b] Numbers for these years reflect new editing procedures instituted by the Bureau of Census in 1986 for cases with missing data on school enrollment items.

Figure 2-24.
High School Completion at Age 28 to 29 (by race and ethnic group) (percentage of total subgroup population)

The percentage of the three major racial and ethnic groups of 18- to 24-year-old people that go on to college after completing high school is shown in Table 2-2. Since 1980, all three groups show increased rates of participation in higher education. The rate for blacks is down slightly in 1980 and 1985, then up in 1990. Preliminary information indicates that, in the 1990-91 school year, the percentage of black students going on to college has declined slightly.

Table 2-2.
Participation Rates of 18 to 24-Year-Old Adults in Higher Education (by race and ethnic group) (percentage of each total subgroup population)

Group	1970	1975	1980	1985	1990	1991[a]
White	27.1	27.4	29.3	30.0	35.2	36.8
Black	15.5	20.4	19.4	19.6	25.3	23.4
Hispanic[b]	N/A	20.4	16.1	16.9	16.2	17.8

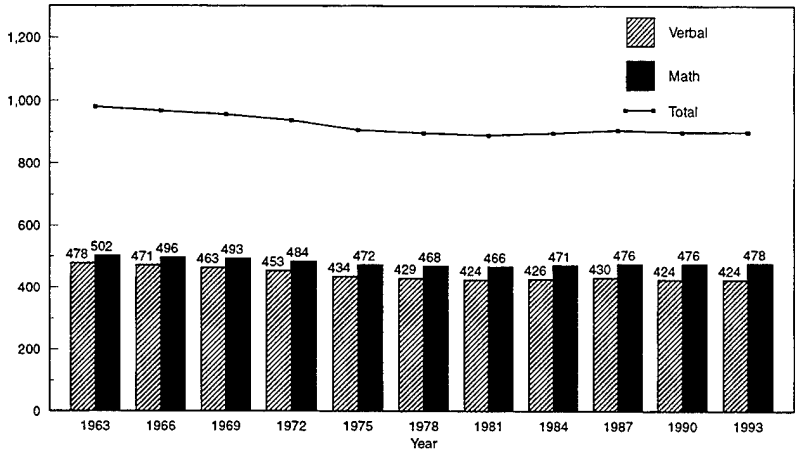
Source: Snyder (NCES 93-292). p. 187.

Note: N/A = not available.

[a] Preliminary data.

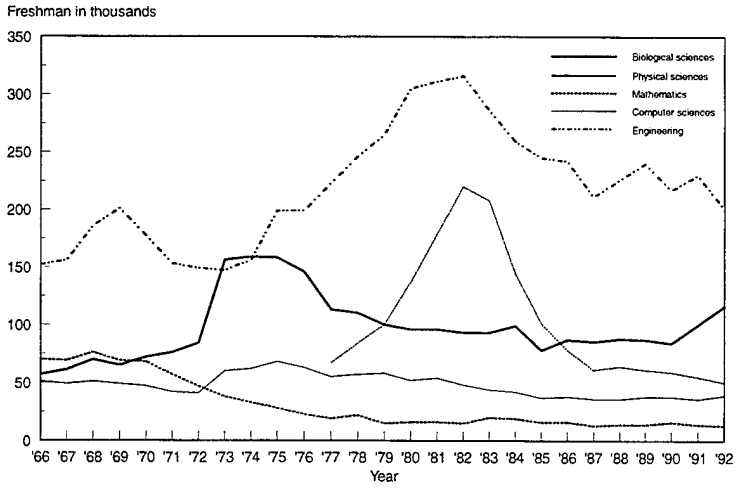
[b] Persons of Hispanic origin may be of any race.

Figure 2-25 shows recent trends in the national mean scores for the Scholastic Aptitude Test (SAT) taken by college-bound young men and women. Figure 2-26 contains similar information for the American College Testing (ACT) Assessment Program. While the latest results of both tests are a little better than the lows of 1980, the continued disappointing performance by our youth on these standard measures causes widespread concern in the United States. The scores do not show significant improvement in spite of genuine interest and attention by educational systems and institutions, by families, and by the national press.



Sources: (1963 – 1987) Baker (NCES 89-653), pp. 27 and 162; (1990 – 1993) Educational Testing Service.
Note: SAT = Scholastic Aptitude Test of the College Entrance Examination Board.

Figure 2-25.
National Average SAT Scores (1963 through 1993)



Sources: (1970 – 1988) Baker (NCES 89-653), pp. 27 and 163; 1993 ACT.
Note: ACT = American College Testing Assessment Program.
[a] Prior to 1990, the reading test focused on social studies. Subsequent to 1990, the reading test included prose fiction, humanities, social studies, and natural sciences.

Figure 2-26.
National Average ACT Scores (1970 through 1993)

The scores attained by 17-year-old students in standardized mathematics and science tests show similar trends. Table 2-3 displays some of the results of tests reported by the National Educational Testing Service for the National Assessment of Educational Progress.

Table 2-3.
Proficiency of Students 17 Years Old (national average scores)

Subject area	1970	1975	1980	1985	1990
Science	305	296	290	283	290
Mathematics	N/A	304	300	299	305

Source: Owen, Eugene H., *Trends in Academic Progress: Achievement of American Students in Science, Mathematics, Reading, and Writing.* Washington, D.C., National Center for Education Statistics (NCES 91-1264), Sept. 30, 1991, p. 19.

Note: N/A = not available.

In recent years there has been a movement by some states and school districts to require more mathematics and science courses for high school graduation. Table 2-4 shows the national aggregate result for the years 1982, 1987, and 1990 distributed by racial and ethnic group. A significantly larger proportion of all high school graduates completed this "new basics" curriculum in 1990 than completed it in 1982 and in 1987. Black and Hispanic groups of graduates show the highest percentage increases of the groups shown.

Table 2-4.
High School Graduates Earning Recommended Credits in "New Basics"
(by race and ethnic group)
(percentage of graduates in each group)

Racial/ethnic category of students	1982	1987	Percentage change 1982 to 1987	1990	Percentage change 1982 to 1990
All students	13.4	28.6	+113.4	39.9	+197.8
White	14.9	29.7	+99.3	40.6	+172.5
Black	10.1	24.3	+140.6	41.3	+308.9
Hispanic[a]	6.3	17.9	+184.1	32.7	+419.0
Asian	21.0	48.3	+130.0	51.2	+143.8
Others	5.9	28.9	+389.8	26.0	+340.7

Source: Legum, Stanley, et al. *The 1990 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1990, 1987, and 1982 High School Graduates.* Washington, D.C., National Center for Education Statistics (NCES 93-423), April 1993, pp. A-186 and A-187.

Note: Recommended credits in "new basics" include four years of English and three years each of science, mathematics, and social studies.

[a] Persons of Hispanic origin may be of any race.

Table 2-5 compares the percentages of students taking new basics credits in 1982, 1987, and 1990 with the size of the high school graduating populations for the same years. Although the total number of high school graduates in 1990 was 412,000 lower than in 1982, the number of graduates completing the new basics credits increased by 631,000 over 1982. In 1990, therefore, there was a significantly larger pool of high school graduates potentially able to pursue further study in science or engineering than was the case 8 years earlier. These graduates may not be motivated to pursue S&E studies, but as a group they are better equipped to do so, should the motivation come. This real increase in the size of the "potentially able" pool has occurred in spite of the simultaneous decrease in the size of the 18- to 24-year-old cohort already shown in Figure 2-2.

Table 2-5.
Change in Numbers of High School Graduates Earning Recommended Credits in "New Basics"

Year	Number of high school graduates (thousands)	Percentage taking new basics	Number taking new basics (thousands)
1982	3,000	13.4	402
1987	2,700	28.6	772
1990	2,588	39.9	1,033
Change 1982 – 1990	– 412	+26.5	+631

Source: *Number of high school graduates:* Snyder (93-292). p. 108. *Percent taking new basics:* Legum (NCES 93-423), pp. A-186 and A-187.

These data would seem to suggest that U.S. high schools are producing graduates with greater quantitative reasoning ability as time goes on. If that is true, why then have national standardized scores continued their flat-to-downward trend? One might expect improving performance in the mathematics subtests of both the SAT and the ACT between 1982 and 1990 (the years represented in Table 2-5) as a demonstration of the impact of the additional year of mathematics represented by the "new basics" curriculum. A close examination of the period 1982 through 1990 in Figures 2-25 and 2-26 does reveal mildly positive trends in mathematics subtest scores for both standardized instruments. While this growth is not too impressive, it does seem to show that the "new basics" is not harming students' mathematical reasoning capacities and may be starting to help.

College Freshman Interest in Science and Engineering

The American Council on Education and the Cooperative Institutional Research Program (CIRP) of the University of California, Los Angeles conduct an annual survey of freshman college students. This recurring national survey

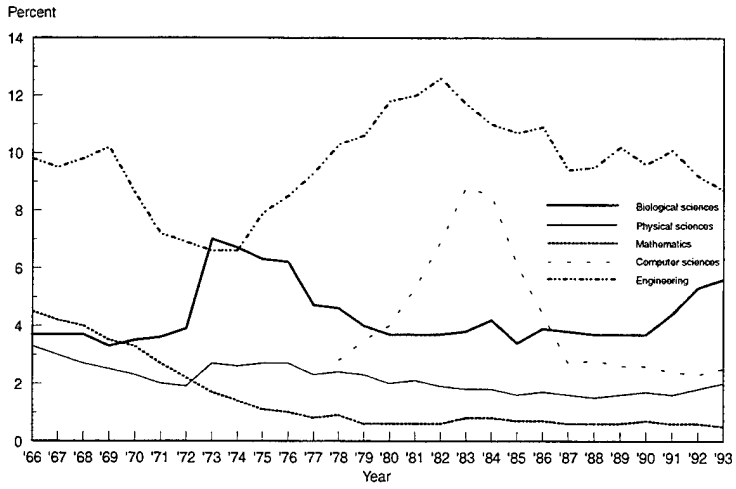
examines characteristics of over eight million students at 1,300 institutions. A part of this continuing study assesses freshman interest in pursuing careers in science and engineering.

The first CIRP data on S&E interest were produced in 1966. During the period 1966 to 1989 they show:

- Interest in fundamental undergraduate science majors among college freshmen has dropped dramatically over the past 23 years.
- Interest in technology careers has declined over the past 6 years.
- More than half the students who enter college planning to pursue science majors change to nonscience fields.

This drop in S&E career interest, when coupled with reduction in the size of the 18- to 24-year-old cohort, causes concern about future S&E baccalaureate degree production.

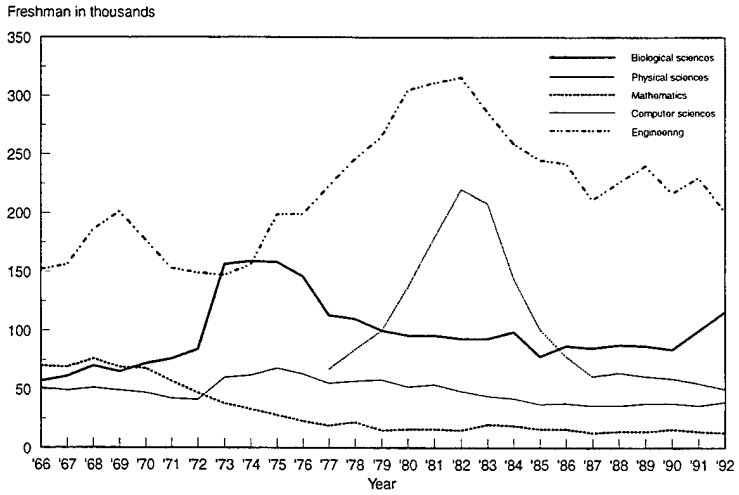
Data from the CIRP surveys are shown in Figures 2-27 and 2-28. Figure 2-27 shows the CIRP responses as percentages of all entering freshmen in the United States. Figure 2-28 displays the number of freshmen expressing the preferences shown.



Source: *(1966 – 1987)*: Cooperative Institutional Research program (CIRP), Higher Education Research Institute, University of California, Los Angeles, CA; *(1988 – 1993):* Astin, Alexander W., et al. *The American Freshman: National Norms for Fall 1988, 1989, 1990, 1991, 1992, 1993.* Los Angeles, CA: University of California, Los Angeles, CA. Cooperative Institutional Research Program; and (freshman enrollment): Snyder (NCES 93-292), p. 183.

Notes: See Table C-11, Appendix C for supporting data. Each annual entering freshman population equals 100 percent.

Figure 2-27.
Freshman Interest in Science and Engineering as Academic Majors (each annual entering freshman population equals 100 percent)



Source: *(1966 – 1987)*: Cooperative Institutional Research program (CIRP), Higher Education Research Institute, University of California, Los Angeles, CA; *(1988 – 1993):* Astin, Alexander W., et al. *The American Freshman: National Norms for Fall 1988, 1989, 1990, 1991, 1992, 1993.* Los Angeles, CA: University of California, Los Angeles, CA. Cooperative Institutional Research Program; and (freshman enrollment): Snyder (NCES 93-292), p. 183.

Notes: See Table C-12, Appendix C, for supporting data. Data for 1993 not available.

Figure 2-28.
Freshman Interest in Science and Engineering as Academic Majors (by year and selected field — numbers of students interested in each subject area) (by thousands)

These data reflect decreases in student interest in the physical sciences and mathematics since 1966 and in computer science since 1983. Examination of the data by discipline reveals the following points:

- *Computer Science:* Interest in computing is back to its level of 1978. The last few years have been essentially level. The CIRP data may be reflecting the fact that much computing effort is now integrated into the teaching of other disciplines, while the focus of computing instruction has shifted somewhat from programming to applications. Therefore, students may be pursuing computer science "... as a means to an end rather than an end in and of itself...."[6]

- *Engineering:* The interest level in engineering is at about the level expressed in 1960's. Since the enrollment pool is significantly larger than in 1966 (even if down from a 1981 peak) there were about one and a half times the number of freshmen students interested in engineering in 1991 than in 1966 (230,000 versus 152,000). Some decrease in interest was expressed in 1992 and 1993.

- *Physical Sciences:* Freshman interest in physical sciences has varied over the 27 years covered by CIRP data. Current interest in 1991 was higher than any year since 1981. The data do show a decline of only 24 percent from 1966 in the numbers of students interested in the physical sciences,

[6] Green, Kenneth C., "A Profile of Undergraduates in the Sciences," *American Scientist*, Volume 77, September – October 1989, pp. 475 – 480.

however. Since 1985, student interest in this field has remained essentially level until the reported increase in 1993.

- *Biological Sciences:* Freshman interest in these fields shows greater variability than interest in the physical sciences. In this case, interest is now showing large increases, especially in 1991 and 1992. More than 59,000 additional students now express interest in the biological sciences than in 1966.

- *Mathematics:* Mathematics interest shows a more serious downward trend. Current interest is only about one-seventh that indicated in 1966. This reduced interest level has remained almost constant since 1979.

Although we might wish to see greater expressions of interest in S&E careers among college freshmen, these data do show that interest levels may have stabilized over the last 5 to 11 years. In two cases they might actually be increasing.

Does interest in a given career, expressed as a freshman, persist through the collegiate undergraduate years? Astin followed the first three CIRP freshmen "generations" through college to determine how durable the CIRP freshman career preferences were. In general, the engineering group was reduced by about 20 percent during the passage of 4 years, while the numbers of students expressing interest in scientific research as a career did not change markedly. Similar levels of continuity are cited by Green in his 1989 keynote address at a professional conference on undergraduate education in science, mathematics, and engineering:

> The CIRP data do predict future trends in the number of earned undergraduate science degrees. Unpublished studies conducted by CIRP staff point to very high correlations (r2 values) between the proportion of freshmen planning to major in science fields and the number of earned undergraduate science degrees four years later (i.e., a four-year cohort approach). These r2 values range from .88 for the biological sciences to .93 for engineering to .98 for computer science.

As some students lose interest in S&E careers, however, others appear who would not have been identified earlier in life as having S&E potential. A 1988 work by the Office of Technology Assessment observes that, "... natural science and engineering attract some new adherents both in the later years of high school and in the early years of college. The die is not cast in the early stages of the educational process...."[7] In this study, nearly 27 percent of eventual S&E graduates enter these disciplines from non-S&E majors after commencing college.

---

[7] Chubin, Daryl E., Project Director. *Elementary and Secondary Education for Science and Engineering — A Technical Memorandum.* Washington, D.C.: U.S. Congress, Office of Technology Assessment, December 1988, p. 12.

INTERPRETATION OF TRENDS

Just what do all these trends mean for the future supply of scientists and engineers in the United States? Are those who anticipate shrinking pools, declining production, and growing shortages to be believed, or is the picture somewhat brighter?

In this atmosphere of countervailing forces and offsetting conditions, several things seem clear:

- The next few years should be watched closely. Many of the disappointing downward trends of the last 15 to 20 years may have bottomed out. We may be seeing the beginnings of improvements in some of the traditional indicators of S&E production. That is true of freshman career preferences and it is true of college participation rates among students.

- The total U.S. population continues to grow, and the growth rate of minorities is significantly higher than that of whites. Since science and engineering students have historically come from the white population, specifically the white male population, either the number of science and engineer students will fall absolutely or another source must be found to replace the declining white male population and that declining portion of white males who choose science and engineering studies. One source for offsetting the losses is women. Greater numbers of women are attending college and greater numbers are enrolling in science and engineering. Another promising trend is increased numbers of racial and ethnic minority members to pursue science and engineering curricula. These numbers have already begun to increase significantly, though the quantities are still small. Since both of these trends are positive, it seems that S&E intervention programs targeting women and minority populations may increase college enrollments and S&E involvement even further.

- More high school students are completing high school, they are doing no worse in standardized tests, and they are completing significantly more mathematics and science courses while in high school. This means the "academically able" pool is increasing even in the face of a decreasing population of 18- to 24-year-old young adults.

The problem, therefore, is how to get more of these better educated youngsters, particularly females and members of underrepresented minorities, to select science and engineering as a college curriculum and life work.

CHAPTER 3

The Science and Engineering Pipeline

INTRODUCTION

The "science and engineering pipeline" is that portion of the formal education system through which students pass on their way to careers in science or engineering. The pipeline contains within its bounds all the students who are equipped, able, and motivated to pursue these careers. It includes at its beginning many children in the early grades of elementary school. It then narrows through a series of attrition and selection processes until it ends by holding only the group of qualified and educated scientists and engineers as signified by the award of baccalaureate, master's, and doctoral degrees.

DESCRIPTION

In the early stages of the pipeline, the students (and any accompanying career desires) are less focused than they are further along the pipeline. Likewise, curricular and career definitions are generalized during the elementary school and early secondary school stages of the pipeline. For example, the terms "science," "natural sciences" and "physical sciences" are sometimes used interchangeably at those stages. At the other, or production, end of the pipeline, however, such generalization and overlapping is neither necessary nor appropriate. But during elementary school, and, to a lesser extent during secondary school, the system emphasizes performance in the sequential mathematics courses, in chemistry, in physics, in computer science, in earth sciences, and (to a lesser extent) in biology or other life sciences. Less concern and attention are devoted to students' interest in courses in the social and behavioral sciences.

The pipeline is more or less continuous through the education process. It contains important linkages or gaps that connect the stages of formal education from kindergarten through graduate school. Losses from the pipeline occur within stages and between stages:

- Within elementary school
- Between elementary and secondary school
- Within secondary or high school
- During the high school-to-college transition

- Within undergraduate college, particularly during the first 2 years
- During the college-to-graduate school transition
- Within graduate school.

These losses occur for several reasons: some students are simply not interested in science and engineering subject matter, others are not academically capable, while still others demonstrate adequate ability but lack the motivation or perseverance to attack what they perceive as "harder" mathematics and science curricula. Those who are not academically capable actually may have avoided the foundational education in elementary or secondary school upon which more advanced study in science and mathematics is based. Other students cannot afford to go to college, while still others never receive the necessary encouragement or impetus to persevere in the more difficult science and engineering curricula. In addition:

> . . . the pipeline is not filled solely by the determined core of committed students who display early promise, high achievement, and drive. Estimates suggest that one-quarter of those who eventually go on to major in science and engineering come from outside the academic (college-preparatory) curriculum track.[1]

Thus, there is a significant amount of elasticity within the pipeline, as well as migration into and out of the pipeline:[2]

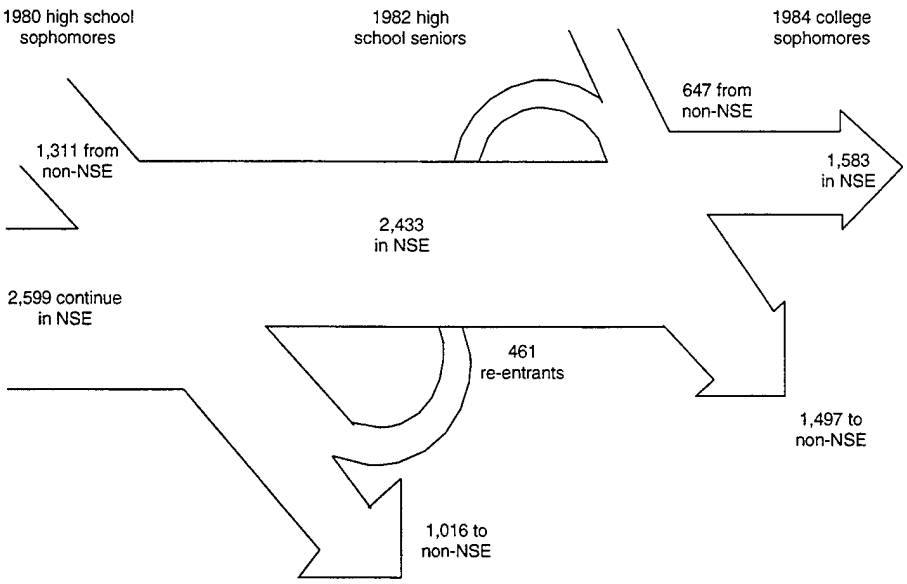
- During high school, as much as 33 percent of the pipeline is made up of students coming from nonscience and engineering curricula.
- By the time students are high school seniors, up to 26 percent have left the pipeline.
- At the start of college, up to 19 percent of the students in the science and engineering pipeline have come back into the pipeline after dropping out previously.
- During college, up to 27 percent of the pipeline is made up of students coming in from nonscience and nonengineering curricula.

Figure 3-1 shows these dynamics. It documents the flow of students into and out of natural science and engineering academic intentions at three points along the pipeline: as high school sophomores, as high school seniors, and as college sophomores.

---

[1] Chubin, Daryl E., Project Director. *Educating Scientists and Engineers: Grade School to Graduate School.* Washington, DC: U.S. Congress, Office of Technology Assessment, June 1988, p. 13.

[2] Chubin, Daryl E., Project Director. *Elementary and Secondary Education for Science and Engineering – A Technical Memorandum,* pp. 10–12.



Source: Chubin, Daryl E., Project Director. *Elementary and Secondary Education for Science and Engineering — A Technical Memorandum.* Washington, D.C.: U.S. Congress, Office of Technology Assessment, December 1988, p. 10.

Note: This diagram traces those students who, at some point, planned to major in natural science or engineering (NSE), out of a nationally representative sample of high school graduates (n = 10,739). "Re-entrants" chose NSE as high school sophomores, abandoned NSE goals as high school seniors, but chose an NSE major in college. Only 300 students, or less than 10%, of those starting, stayed with the same field within NSE at all three time points; the majority of NSE students changed field preferences *within* NSE at least once.

Figure 3-1.
Flow Diagram, 1982 High School Graduates Planning Natural Science or Engineering College Majors (1980 through 1984)

Throughout the length of the pipeline, more than one "pool" of students form the origins of the nation's supply of scientists and engineers. Their composition differs at various stages along the pipeline.

- Three pools of students exist at the *elementary school* level. They are not well-defined and they overlap one another.
  - The talent pool: Those students who have the ability to go on to S&E careers.
  - The academically able pool: Those students who have satisfactorily completed a curriculum with enough academic rigor to be considered "on track" for future S&E curricula.
  - The pipeline pool: Those students who intend to pursue S&E careers.

  At this level these pools are generally considered to be identical in composition and size, except for those few students who obviously perform at a level well below that of the mainstream. Due to the vagueness inherent in students' career plans at this early stage in their

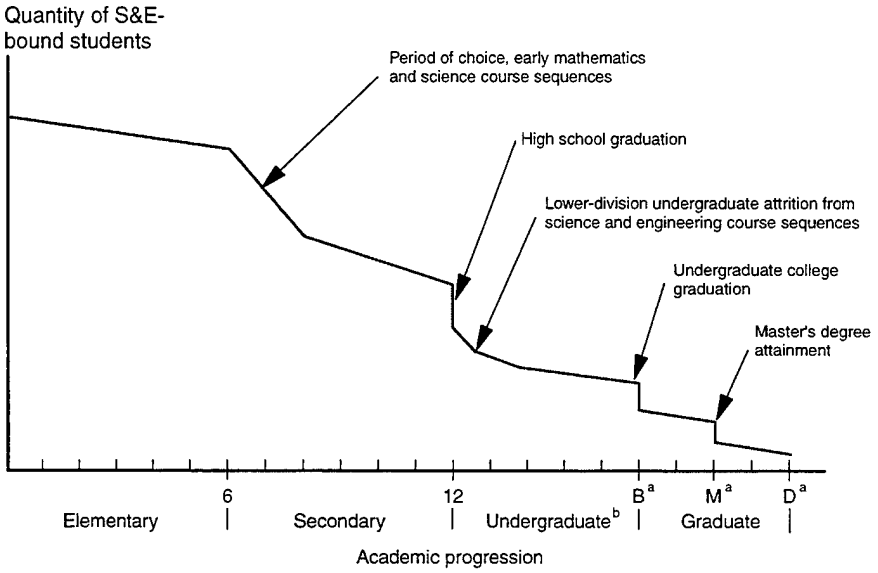
education, and due to the lack of (perhaps the impossibility of) definitive research findings on this same subject, whatever we say about student groups or pools based on a combination of intent and demonstrated academic abilities must be attributed. The characteristics and descriptions we include here about elementary school children are not based on research or survey data.

- During *secondary school,* differences among these pools become evident.
  - The largest group consists of those who could proceed successfully to an S&E career if they would so choose; it is the talent pool.
  - The academically able pool is a large subset of the talent pool. These students have completed – in some cases against their wills – an array of academic courses having sufficient rigor and mathematical or scientific content to equip them adequately to move on toward more advanced S&E curricula should the students choose them.
  - The smallest pool of the three consists of students who actively plan to pursue S&E careers. Those students are generally being counseled to take the proper preparatory courses and they are motivated to continue. They are the pipeline pool.
- Differentiation among the groups continues in *college.* Here, uneven attrition from the pipeline is the norm.
  - The talent pool is of less consequence at this level because the students in that pool are generally headed in various directions with their lives.
  - The academically able group shrinks rapidly because preparatory curricula like the "new basics" are no longer compulsory.
  - The pipeline now narrows abruptly, then more gradually throughout the remainder of the undergraduate experience until graduation. At that point it consists of those men and women who are awarded baccalaureate degrees in scientific and engineering fields of study.

Not long after graduate school begins, two things have happened to the pipeline: its size has been reduced drastically by large numbers of S&E practitioners who choose not to enroll in graduate school, and it has received from outside the undergraduate pipeline a small but persistent number of men and women who have decided late to become scientists and engineers. These people often have undergraduate degrees in the humanities, in business, or in other fields, but they have somehow become redirected in their career choice toward S&E work. The pipeline continues to narrow through graduate school because of natural attrition, until it reaches, respectively, the master's degree and the doctorate. We have chosen not to identify the talent pool, the academically able pool, and the pipeline pool here because it would be needlessly artificial to do so.

Within all these pools, of course, there are a number of different groups, subgroups, strata, or mini-pools. The pools can be subdivided by gender, ethnicity, race, economic status, or by other discriminators. Indeed, a number of existing intervention or encouragement programs are aimed directly at one such subgroup or another.

The S&E pipeline, shown originally in Figure 3-1, contains several points at which substantial reduction or narrowing occurs abruptly. Figure 3-2 is a representation of the entire S&E pipeline.



[a] B = Bachelor's, M = Master's level, and D = Doctorate. Postdoctoral study not shown.

[b] Five years' undergraduate study are shown because many science and most engineering majors require such a period of study.

Figure 3-2.
Notional Reductions in the Science and Engineering Pipeline with Educational Progress

The first major reduction occurs in the early years of secondary school (generally during the 7th through the 9th grades), when students are asked to begin several academic course sequences. In mathematics, for example, students may opt for relatively easy, moderate, or difficult course sequences based on a combination of their own experiences, their long-range academic plans, and their counselors' suggestions. Students enrolled in school systems embracing the "new basics" curricula requirements (see Table 2-5) embark on three or four years of sequential mathematics courses of increasing difficulty. Similar decisions are made for sequences involving the natural and social sciences. This period of choosing by students rapidly reduces both the pipeline population and the academically able pool. It also probably helps to improve or refine the boundaries of the talent pool as well.

The next major narrowing of the pipeline occurs during the time between high school and college. Large numbers of well-prepared, talented students annually forego collegiate study for a wide variety of reasons.

The beginning of undergraduate study, however, offers little assurance of continued success for those pursuing S&E goals. Between the beginning of freshman year and the end of sophomore year, the pipeline (and the academically prepared pool as well) undergo significant shrinkage. Once students successfully begin junior-year studies, however, attrition slows.

Upon graduation from college, of course, a number of S&E pipeline members fall away, having attained their baccalaureate-level goals. The educational gap between undergraduate study and graduate school, therefore, is the next – and last – precipitous reduction in pipeline size.

SUMMARY

The science and engineering pipeline, beginning in elementary school and continuing through graduate education, is approximately 20 years long. There are many opportunities, therefore, to try to influence the pipeline size or volume along the way. Observers do not agree, however, on the location of the point or points at which intervention will have the greatest positive impact.

Increasing the size of the S&E pipeline, for example, can occur in one of two ways. Individuals can be added along the way through recruiting activities, or people already in the pipeline can be retained by efforts bent on reducing attrition. The more immediate payoff can be realized by retaining larger numbers of pipeline incumbents who are relatively close to their goal of graduation as scientists or engineers. It is possible, however, that even larger numbers of scientists and engineers can be produced through recruiting efforts expended earlier in the pipeline. As in many conditions of this type, a combination of both types of activities may prove to be the most useful choice for intervention plans.

In the following chapter, we examine a number of DoD programs that strive either to encourage students to pursue S&E careers in the first place, or to equip students to persevere an S&E curricula already chose.

CHAPTER 4

DoD Science and Engineering Intervention Programs

BACKGROUND

In October of 1989, OASD(FM&P) and ODDR&E requested the Military Services and Defense agencies to submit summary descriptions of their science and engineering educational programs (also called intervention programs).[1] This OSD effort was undertaken largely in response to a congressional request for information on the array of existing DoD programs that promote education and training in the sciences, engineering, and other technical disciplines. The information gathered was also to be used for the analysis of activities that could help DoD planning for ways to meet future technical personnel needs.

The Military Services and Defense agencies submitted information on 136 intervention programs[2] to OSD. Table 4-1 shows a distribution of these programs by reporting agency and educational level.

Table 4-1.
DoD Science and Engineering Intervention Programs Reported to OSD (by educational level and reporting agency)

Educational level	Army	Navy	Air Force	Defense agencies	Total
Precollege	4	11	1	4	20
Undergraduate	1	19	1	8	29
Graduate	9	18	9	14	50
Postdoctoral/faculty	5	11	4	2	22
Other[a]	0	8	0	14	50
Total	19	67	15	35	136

[a] Includes programs with other than educational objectives, such as recruiting, retention, conferences, or publicity.

Reporting by the Military Services and Defense agencies was uneven. The Navy reported many more intervention programs than did the other Services. Our review of all the reported programs, however, revealed that the Navy

[1] Office of the Secretary of Defense (OSD) Memorandum, "Science and Engineering Workforce: Year 2000," 10 October 1989.

[2] A list of the 136 programs reported is included in Appendix A.

reported programs from many different organizational levels, while the Army and Air Force tended to report centrally-coordinated programs. As an example, the Navy reported five cooperative education programs, while the Army reported none, the Air Force one, and the defense agencies two.

Some of the programs were reported more than once. The National Research Council (NRC) Postdoctoral Research Associateship program, for example, was reported once by the Army, four times by the Navy, once by the Air Force, and once by the Defense Nuclear Agency. Thus, Table 4-1 includes this seven times. We consider it a single program.

Two observations are warranted. First, people do not agree on just what constitutes an educational intervention program for scientific and engineering personnel.[3] Second, comparable activities conducted by subordinate organizations within the agencies and the Military Services were not reported in equivalent ways during this exercise.

Of the 136 programs reported, 112 were selected for inclusion in OSD's report to Congress.[4] This list became the original inventory of programs for the current study. The process used to reduce that list is described in the following section.

Final Selection of Programs for Evaluation

It would have been impossible to evaluate and analyze effectively all 112 programs reported by DoD. A representative sample set of programs was therefore selected for detailed analysis. The following criteria were used to reduce the larger list to a more manageable group of 32.[5]

The following kinds of programs were eliminated:

- Those that are not science and engineering educational intervention programs. (A few programs were included in the 112 that, upon closer examination, should have been excluded from the final list.)

- Programs recently initiated (generally after 1985/1986). There are older, better-established programs that promised to provide more extensive data.

---

[3] A working definition of these programs is suggested in a later section of this chapter.

[4] Department of Defense. Report on Science and Engineering Education Activities of the Department of Defense. For the Committees on Armed Services, United States Congress. Washington, DC, March 1990. A copy of this report is included as Appendix G.

[5] A complete program description of each of the 32 programs selected is included in Appendix B.

- Very small programs (fewer than 10 participants annually). Generally, we tried to screen out small programs because it would be more difficult to draw powerful conclusions from such a group.

- Evening tuition assistance programs for staff members (it is very difficult to evaluate these kinds of programs because of their unlimited variability, including the many different educational objectives followed by participants).

- Career development/enrichment programs that are not primarily S&E-directed. (Some such programs, for example, encouraged S&E staff members to become managers.)

- Programs conducted in a highly classified setting. (The National Security Agency reported several potentially attractive S&E intervention programs. For reasons of security, however, we could not have access to personnel data.)

It was also desirable to select programs that were representative across the three Military Departments and the Defense agencies, as well as representative within the four levels of academic achievement: pre-college, undergraduate, graduate, and postdoctoral. Although some of these criteria are subjective, the resulting selections accurately represent the entire list of programs reported to Congress in March 1990. The distribution of the final 32 programs selected is shown in Table 4-2.

Table 4-2.
Distribution of Final Sample of S&E Intervention Programs

Educational level	Army	Navy	Air Force	Other	Total
Precollege	4	4	1	1(DMA)	10
Undergraduate	1	5	1	0	7
Graduate	0	2	4	0	6
Postdoctoral/faculty	2	3	3	1 (NRC)	9
Total	7	14	9	2	32

Note: The NRC program, reported by a total of seven DoD organizations, is counted here as a single program and discussed in the text of the report as a single program.

Definition of Science and Engineering Intervention Programs

Program administrators do not always agree on the meaning or objectives of science and engineering intervention programs. As a result of our work on this study, the following working definition has evolved. We commend it to other researchers in the field.

> Any of a range of specific educational programs – some established through civilian or military personnel channels and some through research and development channels – whose principal focus and objective is to increase the numbers or quality of scientists or engineers within the United States.

Objectives and Effects of Intervention Programs

As stated in DoD's report to Congress, the objectives of these programs are very broad. That breadth

> . . . identifies the fact that the Department of Defense supports a wide variety of programs which involve science and engineering education either directly, such as fellowship support for students or tuition payments for employee training, or indirectly, such as work experience in DoD laboratories or by research performed on DoD grants to universities.[6]

Most of DoD's science and engineering intervention programs are intended to increase the supply of competent scientists and engineers within the United States. These programs have their first impact upon the S&E pipeline at the point where the intervention occurs, but their effect continues "downstream" as well. Examples are the intervention programs that increase the supply of high school students interested in pursuing science or engineering curricula in college. These programs have a potentially dramatic effect on the size of the pipeline from high school onward, even though the population of the pipeline pool inevitably shrinks as the students move through the successive stages of academic life.

Intervention programs that focus on the transitions or gaps in the process also can have positive results, because of the number of science and engineering students that fall away at these critical transition points. Intervention programs aimed at rescuing lower-division college undergraduates from early attrition in tough introductory S&E courses can also pay significant dividends in raising the "throughput rate" in that portion of the pipeline, because without an intervention of some kind, a number of future scientists and engineers are lost to other disciplines. Intervention efforts aimed at upper-division (junior and senior) students, however, probably have a smaller effect on the quantity of S&E graduates than programs whose effect on the pipeline begins earlier.

[6] Department of Defense, p. 9.

In graduate school, where intervention programs are more costly on a per-student basis, many effective interventions are related to concomitant employment conditions and agreements. For postdoctoral fellows, faculty researchers, and similarly experienced personnel, the effect of intervention programs is more likely to be an increase in quality than an increase in quantity. These programs are of additional value, of course, because they initiate or continue research in areas of vital interest to DoD.

Many intervention programs have secondary objectives as well. These include recruiting for the DoD workforce, retaining current qualified employees, interchanging technical information between academia and DoD laboratories, and improving good will for DoD. The proposed definition focuses on the *principal* objective of intervention programs: to increase the number of qualified scientists and engineers, and to improve the quality of the current S&E work force in the United States.

The 32 programs selected for final review reflect the full range of objectives discussed above, but all have the principal objective of increasing numbers and/or quality. It is instructive to review a sample of those objectives as articulated by the implementing office involved. Each program is described fully in Appendix B, including a complete listing of all the objectives listed by the office managing the programs.

Pre-College Program Sample Objectives

- To stimulate interest of outstanding high school students in pursuing careers in science and engineering by allowing them to work on technical projects in an Air Force laboratory environment.
- To better prepare a larger pool of minority students for entry into, and graduation from, schools of engineering.
- To identify high-achieving high school and middle school students with potential and interest in becoming engineers and scientists and to reinforce them in the pursuit of these fields.
- To interest local high school students in science and engineering professions and the Navy as a potential employer.
- To stimulate and encourage the future technical development of our nation's youth.

Undergraduate Program Sample Objectives

- To provide an effective recruiting source to meet long-range science and engineering staffing goals . . . .

- To provide [this laboratory] with a continuing source of entry-level engineers and scientists.

- To provide superior students with a unique plan for earning money needed for college as well as a chance to learn about their chosen careers through related work experience and study.

- To supplement the laboratory's subprofessional staff in support of the Fleet and to encourage students to seek permanent employment upon graduation . . . .

- To increase the numbers and quality of minority college students in S&E with a long-term goal to equip students with [the] academic foundation to pursue successful graduate study in critical S&E needs.

- To provide for the integration of academic studies and Federal work experience . . . .

Graduate Program Sample Objectives

- To increase the pool of U.S. scientists and engineers equipped at the doctoral level to address aero propulsion technology.

- To attract and retain a cadre of high-quality employees by recruiting top graduates, retaining outstanding performers and increasing productivity of in-house personnel.

- To provide opportunities for competitively-selected employees to acquire critical, urgently required, graduate level state-of-the art skills and knowledge in areas essential to accomplishment of [this center's] mission.

- To provide graduate students a means to participate in research at an Air Force laboratory, to further the research objectives of the United States Air Force . . . .

Postdoctoral Program Sample Objectives

- To develop the basis for continuing research of interest to the Air Force at the faculty member's academic institution, to stimulate continuing relations among faculty members and their professional peers in the Air Force, and to enhance the research interests and capabilities of scientific and engineering educators in scientific areas of interest to the Air Force.

- To encourage continued research and study, by recent postdoctoral students in defense-critical areas.

- To provide postdoctoral scientists and engineers of unusual promise and ability opportunities for research on problems, largely of their own choice, that are compatible with the research interests of the sponsoring DoD laboratories . . . .

- To increase the involvement of highly-trained scientists and engineers in disciplines to meet the evolving needs of naval technology.

These objectives – as well as those of programs not listed – are broad, challenging, even lofty. They are also imprecise. We originally intended to assess how well these programs achieved their stated objectives. That task could not be accomplished, however, because of the vagueness of the objectives.

Authority for the Conduct of Intervention Programs

The DoD has at its disposal a broad range of legal and regulatory authorities to conduct its S&E intervention programs. They range from narrow authority designed for a single purpose to very general authorities that can be used for, among other things, recruiting and hiring scientists and engineers. Appendix D contains a comprehensive list of the legal and regulatory authorities.

Costs of Science and Engineering Intervention Programs

Data provided by the Military Services and Defense agencies in response to the OSD request of 10 October 1989 showed that approximately $340 million had been spent in FY89 on the intervention programs reported. Detailed cost data are presented in the DoD report of March 1990, included in this report as Appendix G.

Our review of the 32-program sample of intervention programs included a review of program costs with each program manager. Data from those interviews generally support the reported costs in detail. The costs associated with programs in the sample are outlined in some detail in Appendix B.

Chapter 5 presents the results of our review of the 32 S&E intervention programs. Those results form the foundation of our recommendations on how DoD can use and manage these programs more effectively. We present those recommendations in Chapter 6.

CHAPTER 5

Results of the Review

INTRODUCTION

In Chapter 4 we described the formal objectives of DoD's educational intervention programs for scientists and engineers. We also followed the 32-program sample selection process used for the present project, because from the outset it was clear that we needed to focus upon as representative a set of programs as possible if we were to produce powerful and helpful assessments. This chapter is the story of what we found.

DEVELOPMENTAL TASKS

In order to better understand the relative effect of any of DoD's intervention programs on individual students in science and engineering, we identify three overarching and related developmental tasks that students accomplish as they move along:

1. First, they develop interest and abilities in the scientific method; in the increasingly difficult mathematical tools to be used in their future careers; and, finally, in the study of how things work, of why events occur as they do, and of the way existence fits together. This accomplishment creates a pool of students who are academically able and interested in further study of science and engineering and ultimately in science and engineering careers.

2. Some students then complete the academic preparation of the baccalaureate programs peculiar to scientists and engineers. Achievement of this task results in a pool of entry-level scientists and engineers more or less adequate to meet the demand for specialists with these qualifications.

3. Finally, some move on through graduate degree programs thereby increasing the quality of the existing (baccalaureate) pool of scientists and engineers. Others pursue research experience.

Accomplishment of these tasks begins in elementary school, continues in secondary school, and stretches through undergraduate and then graduate study. It culminates in academic degrees up to the doctorate (for some, in professional registration, licensure, or certification). Continuing study related to research opportunities permits further development for a few S&E professionals.

These tasks are not always accomplished in sequence. Some are interrupted by part-time work, full-time work, or by alternating periods of study and work. The development of experienced scientists and engineers therefore represents a continuum that starts early and contains several phases and transition points. If they are to be successful, intervention programs must be tailored with care for students involved in a specific phase, or the programs should be designed to help in furnishing assurance to capable students that they can pass successfully from one phase to another. Large numbers of losses are now occurring at these transitions or gaps between phases.

Figure 5-1 displays our concept of this continuum and the interrelationships among developmental tasks, educational phases, and representative types of intervention programs now conducted within DoD

Relationships Among Programs

A closer examination of DoD's intervention activities permits an observer to infer some general relationships and developmental processes among the 100-plus programs themselves. Those relationships are depicted graphically in Figure 5-2. All DoD programs in this area are committed to the general, foundational purpose of increasing the quantity or quality of scientists and engineers in the United States. Some of the programs and activities are shown standing early and alone, apart from the school-related activities that follow. Apart from these, however, the S&E intervention programs of DoD flow inexorably into one another throughout all phases of educational development. Communication is not particularly good among the programs, although a number of program directors and administrators are acquainted with one another. But program objectives and purposes seem to be blended in the ways shown in Figure 5-2. The programs naturally operate to achieve their own objectives, though few of these objectives are articulated with precision, even within the programs themselves. We have shown four major or primary objectives that can be said to represent any of the programs or activities conducted within DoD. In addition, however, Figure 5-2 displays seven lesser or secondary objectives characteristic of many of the programs. In most cases, these goals were inferred through discussions with directors and the review of program activities.

As high school students start taking courses as prerequisites for college, and as some of these students become involved in some of the DoD-sponsored high school apprenticeship or educational programs, DoD's interest in the students' potential increases. These students represent not only possible future scientists and engineers as part of the nation's pool, they also represent possible future employees or researchers for DoD as well. Therefore, the intervention programs applying to the pre-college and undergraduate phases of education and work produce some of their most important results in the recruiting of qualified scientists and engineers for the DoD work force, either as employees or as contract researchers. Later, once recruiting efforts have been successful, other

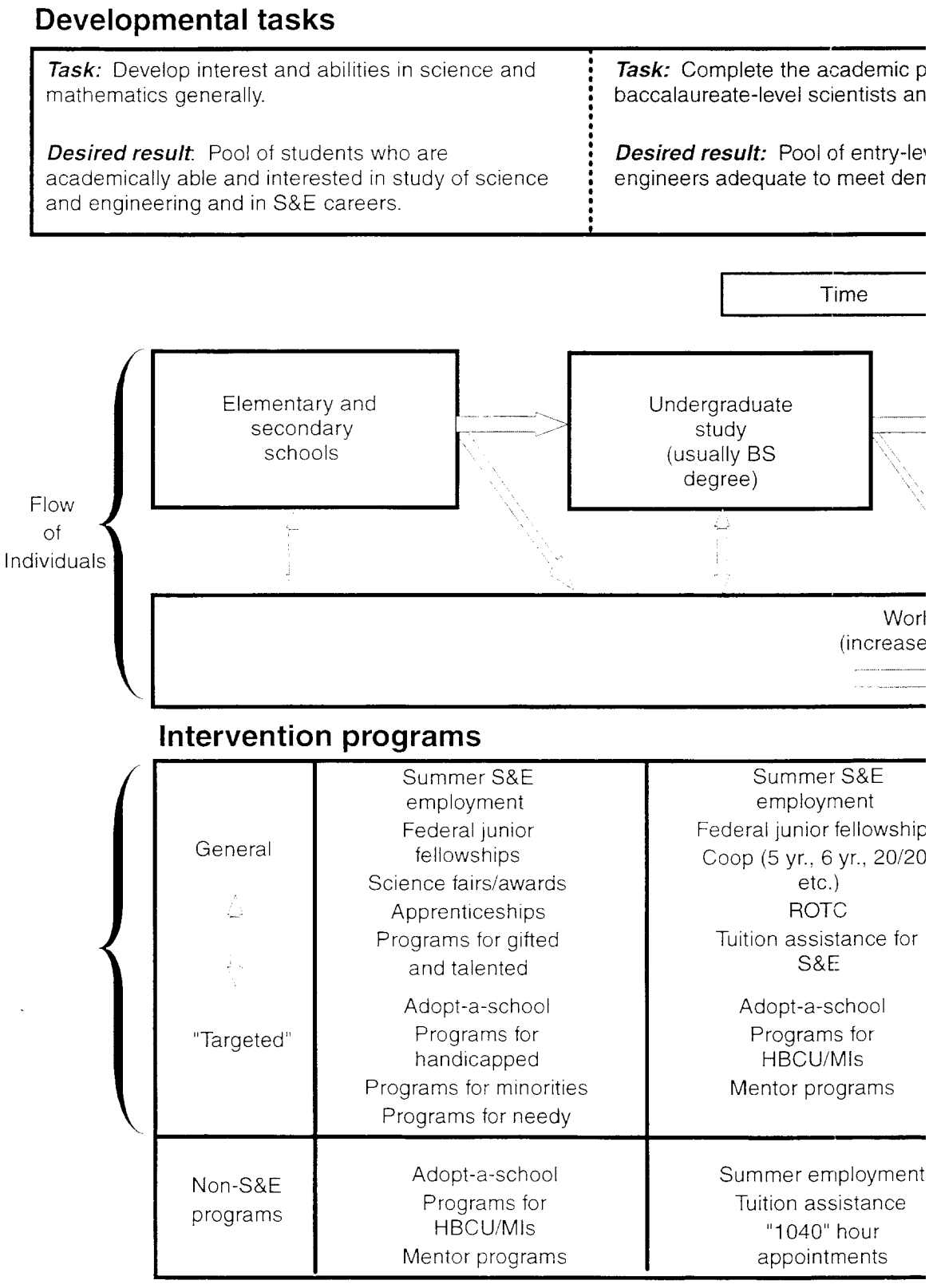
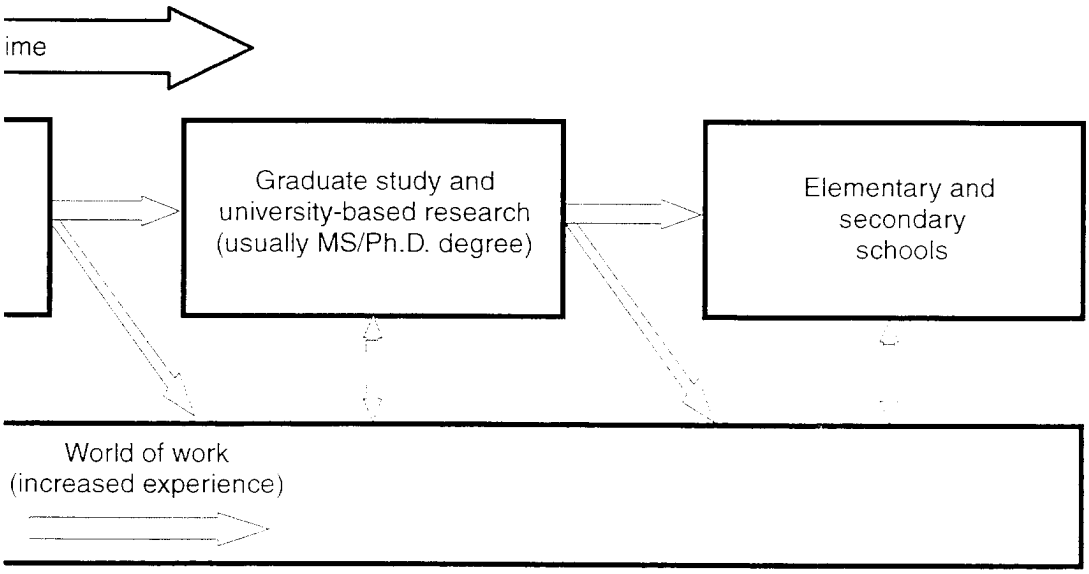


Figure 5-1.
Interrelationship of Education, Work, and Intervention Programs

;ademic preparation of entists and engineers.)f entry-level scientists and meet demand.	***Task:*** Increase the quality of the existing pool of scientists and engineers. ***Desired result:*** Further qualification of scientists and engineers through graduate degree programs and research experience.



S&E ıent fellowships yr., 20/20,) C :ance for : chool s for Mls grams	Graduate fellowships NDSEG fellowships Coop (20/20, 16/24, 1/1, etc.) Tuition assistance for S&E Internships for S&E Programs for HBCU/MIs	Postdoctoral (research) Research associate (research) Summer faculty (research) Programs for HBCU/MIs Nonfaculty programs
ployment istance hour nents	Career item programs Tuition assistance	Adopt-a-school Programs for HBCU/MIs Mentor programs

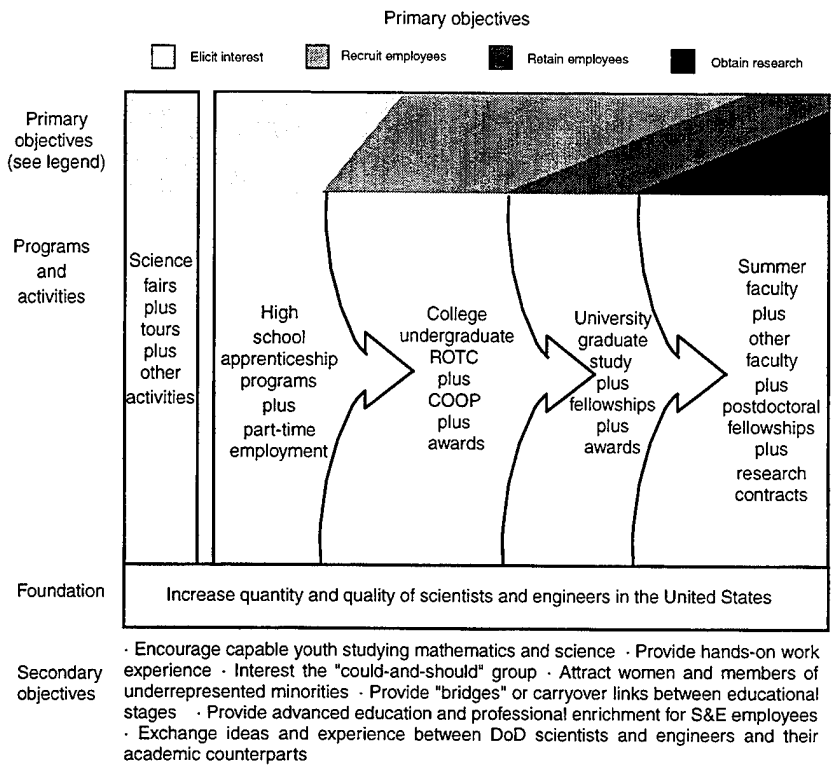


Figure 5-2.
DoD Science and Engineering Intervention Program Relationships

intervention programs related to some undergraduate programs and to manyapplying to the pre-college and undergraduate phases of education and workproduce some of their most important results in the recruiting of qualified scientists and engineers for the DoD work force, either as employees or as contract researchers. Later, once recruiting efforts have been successful, other intervention programs related to some undergraduate programs and to many graduate study programs act to help retain the program participants as DoD workers.

DoD often purchases research effort or research products from individuals. The resulting contracts are sometimes called fellowships or associateships and are commonly considered S&E intervention programs by their sponsors. The programs typically bring about a lively exchange of ideas and techniques between the researcher (who is often a postdoctoral or faculty fellow) and any DoD laboratory or other research employees who are involved in the work. In these cases, the work product or effort is the primary or announced objective of DoD sponsorship, but the accompanying benefit to DoD local work cannot be ignored. The individuals attracted to these kinds of arrangements with DoD may or may not have worked with (or for) DoD before. They become potential future employees and potential future contract investigators because of their DoD interest at this point in their careers.

PROGRAM OBJECTIVES

The overt objectives of most of the intervention programs are to recruit, to retain, or to purchase research. In addition, however, we note several other, often unstated, secondary objectives. These important objectives include, but are not limited to, the following:

1. Encourage capable youth studying science and mathematics subjects.

2. Provide hands-on work experience.

3. Interest and motivate the "could and should" group of talented students who may not be displaying their academic abilities fully.

4. Attract members of underrepresented minorities and women to the study of science and engineering.

5. Bridge the gaps between educational phases with encouragement and continuing contact for students.

6. Provide advanced education and professional enrichment for S&E employees of DoD.

7. Exchange ideas and experience between DoD scientists and engineers and their academic counterparts.

From another perspective, these objectives can be seen as interlocking or overlapping circles, as shown in Figure 5-3.

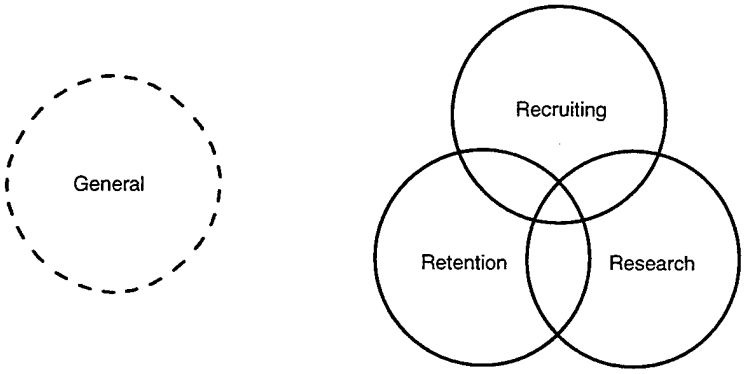


Figure 5-3.
Science and Engineering Intervention Program Objectives

The programs with "general" or truly broad objectives include those that emphasize interest in and exposure to scientific or engineering careers. These programs include science fairs, science awards, symposia, student research papers, and tours of laboratories and other research activities. Continuing education programs like part-time or evening tuition programs (where some uncertainty over the educational goals of the participants exists) are also included. All of these programs are not focused primarily on scientific and engineering education. They all have other, more general objectives, in our opinion.

The primary objectives of all the rest of the S&E programs reviewed overlap with one another. They all involve recruiting, retention, or research. The sponsorship of contract research, for example, does not simply produce a research product usable to the sponsor. It also encourages and supports men and women who are furthering their own knowledge of the sciences or of the engineering fields. In addition, these activities provide for an interchange of technical information with DoD staff members. In many secondary ways this research can result in enlargement of the S&E pool. Of course, relevant research of high quality can also result in increased retention of current employees, and it can produce increased attraction by quality scientific and engineering recruits to the local work force.

Many of the same things can be said of other types of programs, such as some high school apprenticeship programs. In this case, hands-on research work in DoD and university laboratories provides some research products and research support. It further retains young persons in (or attracts young persons to) the S&E pipeline, and it can result in future employees or researchers for DoD.

These interrelationships of recruiting, retention, and research seem to provide the basis for most of the S&E intervention programs within the DoD. Without at least one of these primary objectives, supported by one or more of the secondary objectives we have discussed, the program would fall outside the working definition of intervention programs suggested in Chapter 4.

Program Evaluation Criteria

The evaluation of DoD's educational intervention programs for scientists and engineers can be summarized first by two simple questions:

1. Are the programs effective in encouraging (a) entrance into science and engineering study or (b) persistence in those fields, once entered?

2. Do the programs contribute measurably to DoD's scientific and engineering work force?

To address these two questions in detail, the following program evaluation criteria were developed and used to assess each of the 32 selected programs.

- *Documentation.* How extensive is the documentation of the program? How precise is that documentation?

- *Objectives.* How clearly are the program's objectives stated? Can the achievement of those objectives be measured quantitatively?

- *Management Plans.* How thorough are the program's management plans? Are they followed in practice?

- *Participants.* What criteria are used for selecting program participants? How complete are the data relating to selection?

- *Measures of effectiveness.* Does the program have established measures of program efficacy? To what extent are those measures plausible?

- *Costs.* What are the (annual and per-participant) costs of the program?

Assessment of DoD's S&E intervention programs was accomplished through visits to program directors or administrative managers of the 32 programs. We reviewed each program in the light of the above criteria. In the paragraphs that follow, the programs will be discussed according to the following groupings: pre-college, undergraduate, graduate, and postdoctoral. Within each group, the programs are discussed in clusters according to type of program (e.g., S&E interest-producing events, apprenticeship programs, cooperative education programs, and grant programs).

Characteristics of the Sample Programs

Pre-College Programs

Pre-college programs take on one of three characteristics:

- Interest-producing events or ceremonies, including fairs, awards, symposia, presentation of papers, visits, and tours,

- Apprenticeship programs, which include hands-on work at either Government or university laboratories under the support or guidance of a designated mentor or supervisor, or

- Academic preparation, such as remedial education, preparatory education, and orientations and lectures.

Interest-Producing Events

This group of programs involves science fairs, science awards, scientific and engineering symposia, and demonstrations. Typically, these efforts are directed toward junior and senior high school students; they also sometimes feature members of underrepresented minorities, women, or gifted students. Student participants are not employed by the Federal government in any way. The DoD typically provides only encouragement, support, and prizes for these programs. At the science fairs, for example, volunteer counselors, judges, and experts (who may be military members or DoD civilian scientists or engineers), are made available to help manage the event, to judge entries, and to award prizes provided by DoD. For demonstrations, DoD volunteer researchers conduct certain scientific or engineering experiments or displays before groups of visitors. DoD involvement for all these programs typically consists of volunteer manpower plus some logistics and support funds, including the purchase of prizes and awards.

These programs aid in stimulating interest in science and engineering and in building good will for DoD. There is normally no attempt to follow these students (even those winning prizes) to further encourage their entrance into science and engineering college curricula or to encourage them to participate in apprenticeship programs, or in cooperative work/study programs or ROTC programs during their college years.

Relatively little money is spent on these programs, although the Navy does offer scholarships to some of these students. These types of programs do not provide long-term encouragement because they normally do not provide a mentor or "exemplar" or any other source of continuing, year-round contact with students. The efficacy of these programs is simply unknown. We know of no longitudinal studies to determine whether the programs produce measurable increases in the ranks of scientists and engineers. DoD's role in supporting activities like science fairs is good public relations work. Along with those of the other agencies and organizations providing support, the DoD efforts will undoubtedly continue.

Apprenticeship Programs

This group of programs provides high school and college students with work experience (normally during summer vacations) assisting Government or university technical employees. Some provide special courses to prepare students for college-level scientific or engineering study. In some programs, students are employed as temporary Federal civilian employees; in others, they are employed by a contractor who pays the students and arranges for their work in DoD or university laboratories.

These are hands-on, work-related programs in which the student is typically assigned to a mentor. In some of these programs, the mentor retains contact with the student during the ensuing academic year, offering advice and further

encouragement to go on into science and engineering study when in college. For all students — but especially important for economically disadvantaged students — the stipend offered during the summer program provides financial aid that can be used for college-related expenses.

Apprenticeship programs are now widely used throughout the DoD laboratory system. In addition, the Army and Navy have expanded their respective programs to college campuses where academically able minority students are provided work/study experience.

Laboratory personnel often support these programs enthusiastically. This enthusiasm sometimes leads the participating laboratory to provide additional funds to enrich its own local program. In that way, more apprenticeships can be provided than the central funding authority could otherwise support.

Academic Preparation Programs

These programs are limited to providing academic instruction to participants to help prepare them academically to pursue an S&E curriculum in college. A few programs provide only remedial or "catch-up" instruction, while others are careful to select academically promising students at the outset; they then provide enriching, advanced instruction. Some program managers have little trouble finding academically able students, including minority and female students.

Undergraduate Programs

The several variations of undergraduate programs reviewed are designed to encourage even more students to become scientists or engineers. They may be divided into the following categories:

- ROTC scholarship programs
- Cooperative education programs
- Employee study programs
- Summer employment programs
- Historically black colleges and universities (HBCU) and minority institutions (MI) programs.

ROTC Programs

ROTC programs support large numbers of baccalaureate-level science and engineering graduates. Scholarships are offered, with a large percentage of scholarships annually awarded to persons pursuing S&E curricula. ROTC is offered by each of the Military Departments: Army, Navy, and Air Force. Some prospective Marine Corps officers participate in the Naval ROTC program. ROTC graduates must serve in the armed forces for at least four years. Some are assigned to the active forces while others, principally in the Army, serve only as members of the reserve forces.

The Army is now conducting a unique ROTC-related program for some undergraduate students majoring in S&E fields. If interested and qualified, participants are offered special student stipends in return for completing the ROTC curriculum and serving several years following graduation in the Army Reserve or Army National Guard, while simultaneously accepting employment in the appropriate scientific or engineering field at a specific Army laboratory. The individual student arrangements for this program are made between the participating laboratory and the student's college or university, with coordination through the Cadet Command of the Army's Training and Doctrine Command. Some laboratory work during the student's vacations is also required.

Cooperative Education Programs (COOP)

Traditional collegiate COOP programs[1] are focused upon agreements between the employing organization and the college. These typically call for a specified curriculum, an alternating work/study cycle (often one semester at a time), and the promise of a job within the organization after completion of a baccalaureate program in the agreed curriculum. Today many variations of this kind of program exist. They permit reduced work periods, work-with-simultaneous-academic-study, five-year programs, and even six-year programs. Overall, they offer broad, powerful, and flexible incentives for channeling undergraduate students into S&E curricula. These programs are also a rich source for Government employees in the S&E fields, and they are also used successfully for encouraging members of underrepresented minorities and females to complete S&E curricula.

Undergraduate Study Programs for DoD Employees

Employees of the Federal government may be given assistance in pursuing undergraduate study while retaining employment. This can involve either part-time or full-time study. Full-time programs provide for continuation of salary plus tuition and other educational expenses and can be used for one year at a time. Employment payback time, at the rate of three years' employment for

[1] See Title 5, U.S.C., Chapter 41, and Code of Federal Regulations, Title 5, Part 213, Section 3202 (5 CFR 213.3202).

each year of full-time study, is required for participation in these programs. While these programs are popular where they are offered, full-time study is used more often for graduate study, as described in a later section of this chapter.

These undergraduate programs have several distinct benefits. They help increase the supply of baccalaureate-level scientists and engineers through the educational upgrading of members of the technical staff. They also serve as retention programs for the most capable and aggressive subprofessional employees. Finally, they provide one means for members of underrepresented minorities and female employees of the laboratories to complete degree programs in science and engineering.

Summer Employment Programs

College students can be hired by the government for summer work programs. Students are temporary employees (excepted service, Schedule A) and are limited by law to a maximum of 1,040 hours of this kind of work per year. There are, however, only a limited number of organized programs for encouraging and assisting college students already embarked upon undergraduate curricula in science and engineering. For students who will not or cannot participate in ROTC or COOP programs, summer (or other vacation) employment is a very important source of experience and financial assistance. Summer employment programs are not organized into any centrally-managed endeavor. The programs do not employ mentors, as do the best high school apprenticeship programs and some college internship and work-study programs.

Assistance to HBCU and MI

These programs channel financial assistance to historically black colleges and universities to enrich and assist these institutions, "particularly in the fields of science and technology . . . ."[2] Some accomplish this task by providing graduate and undergraduate students with part-time or summer employment positions in the Federal government. Other programs concentrate on the improvement of the educational infrastructure at HBCUs through the purchase of new equipment, building renovation and construction, and the attraction of high-quality faculty members with the use of increased funding. Additionally, program funds are used to assure greater access to science and engineering curricula by providing financial aid to needy students. Some programs are conducted for the benefit and growth of MI as well as HBCU.

---

[2]Title 20, U.S.C., Section 1060, Congressional Findings and Purposes, (Codifies Executive Order No. 12677, 28 April 1989, 54 Fed. Reg. 18869).

Graduate Programs

The range of graduate intervention programs is very similar to the range of undergraduate programs, except that ROTC is not generally available to graduate students, while fellowship grants are not often available for undergraduate study. The graduate programs of DoD can be grouped into the following broad categories:

- Cooperative education programs
- Employee study programs
- Summer employment programs
- Research
- Historically black colleges and universities (HBCU) and minority institutions (MI)
- Grant or fellowship programs.

Cooperative Education Programs (COOP)

As is the case with undergraduate programs of this kind, graduate COOP programs provide a work/study opportunity for assisting graduate students in their S&E study. Employees can alternate work and study in a very flexible way while pursuing graduate curricula. In addition, the Air Force has COOP programs that support selected graduate students who alternate work at contractor (not just DoD) facilities. The COOP programs are very flexible; they are an effective means of increasing the S&E supply through providing encouragement and support.

Employee Graduate Study Programs

Employees of the Federal government may be given assistance in pursuing graduate study while retaining their government employment status. This can be accomplished either part-time or full-time. Full-time programs provide for continuation of salary plus tuition and other educational expenses. Payback time, at the rate of three years' additional employment for each year of full-time study, is required for participating in this program. Used as a recruiting device, these programs can be related to initial employment conditions as well, such as offering advanced educational opportunities at the outset of employment, followed by a specified number of years' obligatory employment under the payback rule.

Summer Employment Programs

Students in graduate programs may be hired by the government for summer work. These students are temporary employees (excepted service, Schedule A) and are limited to 1,040 hours of work per year as a maximum. This type of employment need not be limited to the summer months. Employed students, of course, have the flexibility to work the 1,040 hours in increments: some each week or briefly full-time during a fall, winter or other mid-year break from classes, rather than simply during the summer months. The latter schedule is more normally associated with pre-college or with undergraduate students.

Research Programs

Graduate students can receive research grants to work in DoD laboratories for specified periods of time, either with a Government mentor or alongside an outside researcher who is also working on contract research in a DoD laboratory. These grants or fellowships allow graduate students to earn money — often during the summer — as well as to accomplish research under a more senior investigator. In all cases, a report is prepared by the student at the conclusion of the work. The report is provided to the laboratory involved.

HBCU and MI Institutional Programs

Since these programs are focused on the individual institutions of higher education, they tend to benefit both undergraduate and graduate students at the college or university receiving the help. As a result, we do not distinguish between undergraduate and graduate programs for HBCUs and MI.

Grant or Fellowship Programs

National Defense Science and Engineering Grants are available to promising S&E graduate students. These grants pay a stipend plus graduate tuition expenses for up to three years to assist in completing M.S. and Ph.D. programs. There is no employment requirement for these grants. The course work must be undertaken in technical areas of interest to the specific Military Service or laboratory providing the money for the grant. In addition to encouraging increases in the overall supply of better-educated scientists and engineers, these programs can also produce alumni who eventually work as contractors or independent researchers on other problems of interest to DoD.

Postdoctoral Programs

All the postdoctoral programs reviewed involve research. DoD-sponsored research must have some relevance to the departmental missions. Within these limitations there are many versions of postdoctoral research underway at this

time. Many programs are aimed at obtaining needed research from outside researchers while providing opportunities for fruitful interchanges between military laboratory scientists or engineers and their visiting colleagues, who are often employed by universities.

Some research is done solely at DoD laboratories during summer months. Some work is sponsored for as much as 3 years of full-time effort. A program often supports a researcher who is accompanied by one or more graduate students, thereby supporting graduate work as well as providing the students with exposure to military research. Occasionally, a faculty member whose contract specifies research work performed during the summer months is not able to complete in one summer all the work required. The researcher is then permitted additional time to complete the project at the researcher's university.

Research programs also provide an opportunity to recruit relatively junior postdoctoral personnel for DoD employment. Senior, tenured faculty members are not often attracted to government employment, but their graduate students and postdoctoral fellows occasionally become interested in pursuing government research, some through government employment.

Some of these programs also bring high school faculty members into the laboratories to do research. This activity naturally introduces them to military research needs. These members of the faculty are then better able to guide and encourage their high school students into following S&E careers, some with a DoD orientation.

THE BEST PROGRAMS

Of the 32 sample S&E intervention programs reviewed, 13 appear to be particularly effective. These are indeed superior on the basis of

- satisfying the evaluation criteria presented earlier in this chapter,
- impressions formed during on-sight reviews and discussions with program directors,
- the noteworthy dedication and inspirational leadership of program leaders, and
- the desirability of duplicating or expanding these efforts elsewhere in DoD.

Each of these programs operates at one specific level within the educational process: pre-college, undergraduate, graduate, or postdoctoral. None of the programs dealt primarily with the gaps or transitional points in the process. Finally, none of these exemplary programs tried to reduce attrition, during the first two years of college, from the ranks of students pursuing S&E curricula. These latter areas offer opportunities for the new and innovative programs of the future.

The 13 best programs are grouped and identified below by educational level, along with a short statement of the outstanding characteristics of each program. Complete program descriptions are included in Appendix B.

Pre-College Programs

High School Apprenticeship Programs (HSAP)

Several high school apprenticeship programs operate within DoD. Those we evaluated were well operated. They all have the characteristics of providing hands-on research and development work for participants. They all have mentors assigned to each participant. In some cases the mentors maintain contact with their participants throughout the academic year.

The Army and Navy cooperate in supporting a large HSAP, focused on the Washington, D.C. area, called the Science and Engineering Apprenticeship Program (SEAP). This program, under Navy management, involves approximately 700 high school students at laboratories in the national capital area. The program includes significant female and minority participation. It also targets the "could and should" group of students — those who might not persevere in S&E without the encouragement of this type of effort. This program also employs high school teachers at the larger laboratories to aid in managing the student program. An added benefit is the exposure of these faculty members to Defense research and development work. Contact between faculty participants and students continues during the academic year.

The Air Force, which launched its own HSAP as recently as 1985, has moved rapidly. It now operates an effective program at 15 laboratories across the country. Some laboratory commanders and staff members, initially skeptical, have developed into strong supporters of the program and have committed local resources to its expansion.

The Army, using a not-for-profit contractor, has undertaken a different approach to the HSAP. This program, called the Research and Engineering Apprenticeship Program (REAP), is conducted at several university laboratories by faculty researchers who also serve as mentors. The program, located in areas of significantly high minority population, targets academically able students from these populations. Many of the participants are also socially and economically disadvantaged. This program demonstrates the availability of impressive numbers of academically able minority students who can benefit from an S&E intervention program while still in high school.

Middle School/High School Academic Program

The Defense Mapping Agency (DMA) supports a novel middle school and high school program in the state of Texas, called the Texas Pre-freshman Engineering Program (TEXPREP).[3] This program, operated out of the University of Texas, San Antonio, is now conducted in 19 locations throughout Texas. The program consists of eight weeks of rigorous, college-preparatory mathematics and science courses conducted during three sequential summers.[4] Like REAP, this program identifies and recruits students each year who seem academically able to pursue S&E curricula in college. The students selected (over 2,000 in 1991) have already demonstrated academic capabilities in high school courses, obtaining a minimum of a "B" average. This program uses recently-graduated Naval and Air Force Academy officers as instructors and mentors while those officers are awaiting their first military assignments. The program coordinator carefully follows program graduates. A recent survey shows that 89 percent attend college; of that number, 60 percent are majoring in science or engineering.

Undergraduate Programs

Cooperative Education Programs (COOP)

A variety of COOP programs are now conducted throughout the Federal civilian work force. One of these programs, at the Naval Air Development Center (NADC), is particularly impressive. This is a moderately large effort for programs of this type, with 63 participants (down from a high of 198 several years ago). The program receives positive management support within NADC. Its director participates in a Navy-wide coordination group sponsored by Headquarters, United States Navy. The program also benefits from dedicated, aggressive management. The NADC civilian personnel office will be able to meet most of its Science and Engineering annual new-hire needs — approximately 75 employees — by recruiting NADC COOP graduates if the Center is able to rebuild earlier participation levels. The reduced participation is caused by local rules flowing from a newly-instituted "management to payroll" policy throughout the Navy. NADC data show that scientists and engineers hired through the NADC COOP program remain in government service at slightly higher rates than those hired directly through college recruiting procedures (see Appendix F).

---

[3] The Defense Mapping Agency is only one of almost 150 municipalities, government agencies, educational institutions, private citizens, and private companies now supporting TEXPREP with money or effort.

[4] A recent survey shows that, since its inception as a local program in 1979, 77 percent of TEXPREP participants have been members of underrepresented minorities and 49 percent have been female.

Science and Engineering Cooperative Program (ROTC)

The Army initiated a novel program in 1984 involving Reserve Officer Training Corps (ROTC) graduates in S&E fields who go on to serve in the Army National Guard or the U.S. Army Reserve. These new officers are not sent to active duty with the active forces, but remain in the reserve forces for eight years in repayment for the stipends received during undergraduate study. By blending a version of the regular Army civilian COOP program with the Army ROTC program, however, this program requires its participants to work in Army laboratories during summer (and other) vacations from college and to become full-time employees of a participating Army laboratory as scientists or engineers upon graduation. This program has proven successful in obtaining additional civilian S&E employees for the Army while aiding undergraduate students to complete their studies for S&E baccalaureates.

Graduate Programs

Air Force Research in Aero Propulsion Technology (AFRAPT) Program

This program amounts to a cooperative arrangement to support graduate education in aero propulsion, a field of interest to the Air Force. Five universities and five gas turbine engine companies cooperate in this program. A graduate student applies to the Air Force to study in this field and, if selected, enters a cooperative work/study program, alternating between the selected university and company for a period of up to five years while completing work on a graduate degree. The participant receives a monthly stipend plus full tuition allowances. This program not only increases S&E numbers in the United States, but also provides personnel capable of working on R&D problems of specific interest to the Air Force.

Air Force PALACE ACQUIRE and PALACE KNIGHT Programs

These programs are a combination of recruiting and educational programs in which S&E personnel graduating with baccalaureate degrees are offered Federal employment accompanied by an Air Force commitment for future paid graduate education in return for further continued employment. The overall objective of these programs is to provide "force renewal" of the Air Force's aging S&E talent base over the next decade. The PALACE ACQUIRE program promises one year of graduate study within the first three years of employment. The PALACE KNIGHT program promises one year of graduate study leading to the master's degree immediately upon hiring, followed by two additional years of graduate study toward the doctorate. (These after three more years of employment in the Air Force.) The Air Force sets specific enrollment objectives for each year in both programs. Since establishing these goals in 1986, the Air Force has exceeded every annual objective.

Air Force Graduate Student Research Program (GSRP)

GSRP is linked with another Air Force Office of Scientific Research program called the Summer Faculty Research Program. In the latter program, 150 university research faculty members are invited to do research in Air Force laboratories on subjects of interest to the Air Force. As a part of this research program, each faculty member is encouraged to invite a graduate student to help in the research effort. If the faculty member does not select a qualified graduate student, the Air Force suggests candidates from other sources. The objective is to aid graduate students in completing their studies and to expose the participants to Air Force needs in research. In addition, the Air Force receives high-quality work in high-priority research areas.

Navy Graduate Study Award Program (GSAP)

All Federal agencies may send their own employees to college — for full-time education at undergraduate or graduate level under the authority of Title 5, U.S.C., Chapter 41, and the Federal Personnel Manual, Chapter 410. The Naval Air Development Center manages a robust program of selecting their employees for graduate education in science and engineering fields oriented toward the Center's research objectives. By aggressive use of the regulations that apply, and by obtaining the necessary waivers from the Federal Office of Personnel Management, NADC is able to send a number of its employees to universities throughout the United States where these employee-students pursue master's and doctoral degrees studies in S&E. The employee, in return, makes a commitment for continued employment. The duration of that commitment is related to the length of the educational absence. Thus, the overall pool of high-quality S&E personnel is increased and NADC obtains the services of more highly trained employees. This program is especially good for assisting females and members of underrepresented minorities to pursue advanced degrees.

Postdoctoral/Faculty Programs

Fellowship Programs

The Office of Naval Technology (ONT) operates a unique research/recruiting program called the ONT Postdoctoral Fellowship Program. This program offers a 1-to-3 year opportunity for participants to do applied research at Navy laboratories in areas of interest to the Navy. All selectees are recent (1-to-7 year) doctorate recipients who apply to the Navy through the American Society of Engineering Education (ASEE), acting as the Navy's agent. The ASEE evaluates the applications under ONT oversight and recommends the award of fellowships. Since the inception of the program in 1984, 237 applications have been submitted, 174 offers of award made, and 126 acceptances received. In addition, ONT estimates that over 50 percent of all participants have been hired by DoD and another 6 percent have been hired by other Federal agencies.

RESEARCH ASSOCIATESHIP PROGRAM

All Military Services and Defense Agencies participate in the National Research Council's (NRC) Research Associateship Program. This program provides 2-year grants to selectees (who are within 1-to-5 years of receiving a doctorate) for research on defense-critical subjects. Applications are sent to the NRC for evaluation and ranking. Funds to provide the grants are transferred from the participating military organization to the NRC, which in turn administers the program. DoD receives important research in return for the grants. In addition, some organizations estimate that approximately 25 percent of these program participants are hired as Federal civilian employees.

CHAPTER 6

Conclusions and Recommendations

INTRODUCTION

The conclusions reached during this project are based upon three different sets of experiences by the study team. Most of what follows in this chapter is an outgrowth of our visits with the directors and administrators of the 32-program sample of intervention activities conducted within DoD. Some conclusions, however, bear the marks of our exposure to the imposing volume of national literature and the availability in the local area of both authors and agency officials having extensive knowledge of supply and demand factors for scientists and engineers in this country. Finally, our conclusions are flavored by our own experience with the interrelationships between and among major segments of the staff of the Office of the Secretary of Defense (OSD) and the staffs of the Military Departments and Defense Agencies.

These three influences are interwoven and have become inseparable from all other aspects of the conclusions that follow. The six conclusions are sound, are based on fact and objective judgment, and they lead to five recommendations that should be accepted and implemented.

CONCLUSIONS

1. *There is a rich profusion of educational intervention programs for scientists and engineers. The programs lack integration, interrelationships and coordinating guidance.*

The S&E intervention programs of the Department of Defense are many and varied. It is likely that our starting inventory of 136 programs and other activities is low by several dozen activities, simply because a number of programs were not reported during the 1989 - 1990 call by OSD for information. The reported programs, some of which date from the 1950s, have grown and developed with a high degree of independence, without either the benefit or the impediments that accompany guidance and regulation from above. Almost all lack the kind of program objectives that can be measured objectively. These DoD educational efforts constitute a "family" of activities only in the most general way. They have evolved with richness and with inefficiency. As a group, they need careful and sensitive coordinating guidance from OSD.

2. *There is a basis in law for these programs.*

Many of DoD's S&E educational intervention programs are conducted under regulations or directives published by local authorities or by the respective Military Service or Defense Agency. We have sought, located, and cited (in Appendix D) a basis in Federal statute and – where appropriate – in Federal regulation for all the programs that constitute our sample. There is in those citations a breadth and sweep of authority that permits DoD to mount and sustain a great variety of S&E interventions with different program objectives and dissimilar participant groups. The lack of proper legal authority should not be cited as a hindrance to the establishment of virtually any kind of prospective educational program in this area.

3. *Effective intervention programs have several common characteristics, which tend to vary with the educational level of the program.*

- Pre-college programs

  - Work-study. Challenging academic sessions.

    The best pre-college programs often include a work-study combination arrangement for participants. Many also conduct academically challenging seminars or classes as part of the intervention. Remedial or corrective work has no place in these high-quality programs for students approaching their college years.

    The work-study cycle proves effective because it permits students to be introduced to S&E professions on a real-work basis. Serving typically as interns, assistants, or apprentices, the students in these programs occasionally require protection by program coordinators from being assigned to trivial or marginal tasks by DoD employees at the work site. When these students are accepted by DoD staff members as potential future professionals, and when their experiences at the DoD facility are understood to focus upon the teaching/learning process, the motivational payoff for participants is enhanced substantially. Normally, the periods of employment characteristic of these programs occur during the students' normal vacations from their respective secondary schools. Because of school attendance requirements, the longer periods of work (often a school term in duration) that mark college-level work-study arrangements are not found in these pre-college programs.

    Remedial academic work conducted as part of a program whose purpose is the preparation of future scientists and engineers tends to raise unrealistically high expectations among student participants. The directors of several effective programs aimed at underprivileged, inner-city youth or at members of underrepresented minorities point repeatedly to the existence in our schools of adequate numbers of academically able youth who meet the qualification criteria of programs

like these. These young people may need motivation, but not remediation.

- Year-round contact with mentors.

  Mentors have very important relationships with young people in the most successful pre-college programs. Mentors are often high school science or mathematics teachers recruited to participate in the intervention, or they may be DoD employees who become acquainted with several student participants during periods of employment. Mentors serve as exemplars, as coaches, and as encouragers; they also provide important information about – and linkages with – the intervention program itself.

  The most crucial period of time for the mentor-student relationship is the winter of the student's senior year, followed closely in importance by the summer immediately following graduation from secondary school. Properly coached and motivated mentors continue to show interest in their small families of students as the mentors provide positive carryover contact during their students' preparation for college.

- Avoidance of simple "exposure" to S&E professions.

  Experience has persuaded a number of pre-college program directors that, to be effective, interventions must move quickly beyond the superficialities of tours and visits, through the intermediate involvements of science projects and their accompanying awards, to deeper and more continuing relationships with S&E careers and practitioners. Undoubtedly, young people are occasionally attracted to an S&E career as a result of a visit to a DoD laboratory, but that does not seem to occur often. The important question in this instance seems to be one of cost to DoD versus the return on that investment.

  It may be advisable, of course, to continue and even to augment the public's exposure to the laboratories and similar facilities of the Department of Defense. But these activities can and should be defended and supported on the basis of their resulting positive relations between DoD and the citizenry. Good public relations have substantial importance and they should not be belittled. Neither, however, should public relations activities be depended on to produce in any quantity young men and women excited about careers as scientists or engineers.

- Avoidance of overly restrictive participation criteria.

  If the rules for the selection of participants are too narrow, intervention programs can shrink to activities for the intellectually elite, many of whom have selected college study programs quite early, and all of

whom would quite likely succeed in any of a number of academic fields. These small programs carry a high administrative cost per participant. They can sometimes be blended successfully with neighbor programs that encourage, for example, the "could and should" group of high school students who have ability but who require motivation before pursuing the more demanding disciplines of college undergraduate study.

- Undergraduate programs

  - Employment-related

    Good intervention programs for undergraduate students need to have some obvious relationship to the world of S&E work. This connection may be made through collegiate work-study arrangements with one of several cooperative education programs based on campus. It may be work at DoD facilities, during vacation periods, for which the participant receives a promise of employment consideration upon graduation. It may be through undergraduate scholarships coupled with DoD laboratory (or similar facility) employment, followed by assured employment that begins an agreed-upon scholarship payback period as a DoD employee. Finally, some intervention programs select as participants DoD employee technicians who have yet to complete their college undergraduate programs. These interventions send the participants back to school as bachelor degree candidates in one of the S&E fields with the obligation to return (normally to the same facility) with a reclassification to professional S&E status but with a payback employment obligation to DoD.

- Graduate programs

  - Employment-related

    The kinds of work-study arrangements that produce good results for undergraduate students can be duplicated with graduate students, except that some universities do not encourage graduate students to coordinate efforts of this kind through the institution's cooperative education office. Periods of employment are considered to be just that, and graduate students are expected to manage their own progress toward academic program completion. From the DoD point of view there are the same general kinds of employment relationship possibilities existing for graduate students as for undergraduate students. In-service career development programs involving graduate study for S&E employees of DoD are quite popular. A program of this kind, of course, improves the quality of the S&E work force while not necessarily improving its quantity.

- Research of interest to DoD

  A number of good DoD intervention programs support graduate student research, much of which contributes to degree attainment on the part of the participating students. This work in turn draws the participant into interesting relationships with specific laboratories or similar DoD facilities. A number of these arrangements lead eventually to DoD employment. In these kinds of programs, DoD enjoys the additional benefit of receiving the beneficial product of the research itself, funded in the first place because of its compatibility with DoD missions and its attractiveness to DoD selection juries.

- Postdoctoral and faculty programs

  - Oriented toward recruiting

    Programs for postdoctoral fellows and faculty researchers are typically conducted with collegiality in a mutual-sharing ambiance. This atmosphere, in which all work is nonetheless directed toward the national defense, can attract program participants as potential employees. While "recruiting" discussions are often subtle and casual, just this sort of approach is widely appreciated by the program participants, most of whom are working on research projects. These participating scientists and engineers have either been working alongside DoD employee scientists and engineers, or they will likely have been accomplishing work that they then must defend before DoD employee review groups. The participants' work must ultimately "fit" with similar, mission-oriented work conducted within DoD facilities.

  - Research of interest to DoD

    To an even greater extent than the research conducted by graduate student program participants, the research work accomplished by postdoctoral and faculty researchers is received and assimilated by DoD employees as important contributions to the advance of knowledge. These programs are beneficial both to the researcher and to the DoD sponsor.

  - Involvement of promising graduate students

    Some of the very best programs involving postdoctoral or faculty fellows (other designations are sometimes used) also benefit DoD because they encourage – or at least permit – graduate students to accompany or to work with the principal program participant. Typically, these students are working with the "postdoc" or faculty member back at their respective campuses, with one or two of the students doing independent study or research work along the lines of the work or project on which DoD is seeking assistance. The proposal is prepared and the contract award made with the understanding that

one or more graduate assistants will participate. The outcome quite often has multiple benefits: DoD gets enriched work attacking difficult questions, the principal participant becomes a friend of the Military Service or Defense Agency (and a potential repeating contractor) and the graduate student(s) becomes acquainted positively with DoD as a potential employer upon degree completion, even while receiving important financial support for the graduate study involved.

4. *The point along the S&E pipeline at which the intervention program is applied is important in determining results.*

Programs applied late in the educational process – during graduate school or beyond – produce limited quantitative results on S&E supply for very high per-person costs. Programs applied much earlier in the process – during, say, the pre-college stage of educational development – offer much higher quantitative payoff potential for the money invested. But these early programs tend to be much more complex, difficult to administer, and more challenging to sustain over the years. In addition, the managers of these early-application programs are not as apt to see the same kind of prompt and positive results from their efforts as do the DoD administrators working with graduate students and faculty members.

We believe that the greatest opportunity for good, from the perspective of where to apply aggressive intervention programs, is to be found at the "gaps" or linkage in the educational process. Specifically, programs aimed at about-to-be-graduated high school diploma recipients or at just-graduated baccalaureate degree recipients offer high promise of positive results. It is at these transition points in the pipeline, of course, where the greatest attrition of potential S&E candidates occurs.

5. *Mentor relationships between S&E professionals and student program participants bring positive results.*

Although we have discussed mentor relationships as a characteristic common to the better pre-college intervention programs visited during this project, it is worthwhile also to list these relationships as a positive factor in successful intervention programs generally. The exploitation of mentor relationships, those continuing relationships between students (whether in secondary school or in college) and older S&E professionals (whether employed in high school or college faculties or in the DoD work force), offers an excellent opportunity for the kind of encouragement, support, and examples that can cause the population of future scientists and engineers to grow. Mentor relationships can be particularly important in providing carryover support and encouragement for students during gaps or transitions along the S&E pipeline.

6. *Attrition of S&E-capable college students is too high during their freshman and sophomore years.*

At the present time, too many freshman and sophomore students with adequate promise and academic preparation are discouraged enough to turn away from science and engineering majors while in college. Many are discouraged because these curricula have sobering, work-hard reputations that lead the students to avoid the programs. Some students are discouraged because of their own disappointing performances in introductory natural science, mathematics, or engineering courses; this latter type of attrition is particularly perplexing because a number of these courses in many colleges and universities carry reputations of being more demanding than the curricula for which they act as filtering mechanisms.

None of the existing DoD education intervention programs attempts to address this problem. Indeed, the attrition of the over-optimistic and the ill-prepared early in their college careers rather than later on is an educational good. We should seek it where it does not exist and support it when we find it. Our concern in this instance, however, is with any institutionally encouraged upward "creep" in the zeal with which these well-known courses screen out potential electrical engineers or physicists. The approaches are almost as broad as academe itself, and the instructors and responsible curriculum committees act with all the dedication of standards-enforcers. Yet we are convinced that some students now being turned away should go on to S&E majors, and possibly to S&E careers.

RECOMMENDATIONS

1. The Office of the Secretary of Defense should develop a broad, achievable set of goals and objectives for all of DoD for programs and activities of this kind.

2. The many intervention programs of DoD should be encouraged by OSD to develop generally the characteristics discussed in Chapter 5 and summarized in the preceding section. The DoD components can use these characteristics as a template to help determine the viability of ongoing programs.

3. The objectives of each program or activity should be reviewed. They should be restructured in ways that make their achievement measurable by the application of objective standards by outside reviewers.

4. The Director of Defense Research and Engineering should sponsor an exploration of ways to mount DoD intervention programs aimed at the gaps and other transition points along the S&E educational pipeline. When appropriate ways are found, resources should be provided to support new or altered programs in those areas.

5. The Defense Science Board – and other organizations in which interfaces exist between DoD officials and university or educational association leaders – should be asked to examine and to probe the high attrition phenomenon of lower-division undergraduate students participating in preparatory or screening courses for the sciences, mathematics, or engineering. This examination should be conducted with the objective of ultimately salvaging a measurable number of students of merit now being screened out.

APPENDIX A

DoD Science and Engineering Intervention Programs

DoD Science and Engineering Intervention Programs

Table A-1 lists 136 programs submitted to the Office of the Secretary of Defense (OSD) as representing science and engineering intervention programs operated by the Military Services and Defense Agencies. The Office of the Director of Defense Research and Engineering reported 112 of those to Congress as representative of DoD intervention programs to either increase the numbers of scientists and engineers or improve the quality of existing scientists and engineers.

Because these programs were self-reported by the DoD Components administering them, the list includes some duplicates. In addition, we believe the list is incomplete, primarily because Navy organizations reported substantially more programs than did the Army and Air Force.

LMI selected 32 of these programs for analysis and evaluation. Criteria used for this selection are discussed in Chapter 4. A detailed description of these 32 programs is contained in Appendix B. We believe they are representative of the types of programs operated by the DoD as science and engineering intervention programs.

Table A-1.
DoD Science and Engineering Intervention Programs

Program	Education level[a]	Military Service/ Defense Agency	
Science and Engineering Fairs	Precollege	Army	Army Research
Junior Science and Humanities Symposia (JSHS)	Precollege	Army	Army Research
Uninitiated Introduction to Engineering (UNITE)	Precollege	Army	Army Research
Research and Engineering Apprenticeship Program (RAEP)	Precollege	Army	Army Research
Minorities in Engineering Program (MEP)	Precollege	Navy	Naval Air Develc
Handicap Outreach	Precollege	Navy	Naval Air Develc
Stay-in-School Program	Precollege	Navy	Naval Coastal S
Gould Science Award	Precollege	Navy	Naval Coastal S
Pax-Hi Program	Precollege	Navy	Naval Electronic
Gifted and Talented Program	Precollege	Navy	Naval Research
Student Volunteer Services	Precollege	Navy	Naval Research
Technical Mentor Program	Precollege	Navy	Naval Weapons
High School Apprenticeship Program (HSAP)	Precollege	Navy	Office of Naval F
Science and Engineering Apprenticeship Program (SEAP)	Precollege	Navy	Office of Naval F
Navy Science Award Program (NSAP)	Precollege	Navy	Office of Naval F
High School Apprenticeship Program (HSAP)	Precollege	Air Force	Office of Scientif
Student Aid and Stay-in-School Programs	Precollege	Defense Mapping Agency	Defense Mappin
Texas Pre-Freshamn Engineering Program (TEXPREP)	Precollege	Defense Mapping Agency	Defense Mappin
Adopt-A-School Program	Precollege	Defense Nuclear Agency	Defense Nuclea
National Sciences Resource Center	Precollege	All	Office of the Sec
Science and Engineering Cooperative Program (ROTC)	Undergraduate	Army	HQ U.S. Army
Cooperative Education Program (COOP)	Undergraduate	Navy	Naval Air Develc
Federal Junior Fellowship Program (FJFP)	Undergraduate	Navy	Naval Air Develc
Science and Engineering Summer Employment Program	Undergraduate	Navy	Naval Air Develc
Part-time Undergraduate Study Award Program	Undergraduate	Navy	Naval Air Develc
Federal Junior Fellowship Program (FJFP)	Undergraduate	Navy	Naval Coastal S
Summer Hire Program	Undergraduate	Navy	Naval Electronic
Cooperative Educational Program (COOP)	Undergraduate	Navy	Naval Electronic
Federal Junior Fellowship Program (FJFP)	Undergraduate	Navy	Naval Electronic
PAX-Tenn Cooperative Education Plan	Undergraduate	Navy	Naval Electronic
Cooperative Education Program (COOP)	Undergraduate	Navy	Naval Facilities I
Professional Development Center	Undergraduate	Navy	Naval Facilities I
Undergraduate Academic Program	Undergraduate	Navy	Naval Ocean Sy
Cooperative Education Program (COOP)	Undergraduate	Navy	Naval Research
Federal Junior Fellowship Program (FJFP)	Undergraduate	Navy	Naval Research

[a] Some programs permit participation at more than one academic level: the level shown is the predominant use.

[b] Office or organization administering the program when different from the reporting unit.

Reporting unit	Administering office[b]
search Office	Science Service, Inc.
search Office	The Academy of Applied Science
search Office	Junior Engineering Technical Society
search Office	The Academy of Applied Science
Development Center	
Development Center	
astal Systems Command	
astal Systems Command	
ctronics Systems Engineering Activity	
search Laboratory	
search Laboratory	
apons Center	
Naval Research	
Naval Research	George Washington University
Naval Research	Science Service, Inc.
Scientific Research	Research and Development Laboratories, Inc.
Mapping Agency	
Mapping Agency	University of Texas, San Antonio
Nuclear Agency	
he Secretary of Defense	National Academy of Science & Smithsonian Institute
Army	Personnel Command
Development Center	
Development Center	
Development Center	
Development Cener	
astal Systems Command	
ctronics Systems Engineering Activity	
ctronics Systems Engineering Activity	
ctronics Systems Engineering Activity	
ctronics Systems Engineering Activity	
ilities Engineering Command	
ilities Engineering Command	
ean Systems Center	
search Laboratory	
search Laboratory	

Table A-1
DoD Science and Engineering Intervention Programs (Continued)

Program	Education level[a]	Military Service/ Defense Agency	
1040-Hour Appointment	Undergraduate	Navy	Naval Re
Summer Hire Program	Undergraduate	Navy	Naval Re
Cooperative Education Program (COOP)	Undergraduate	Navy	Naval Se
Cooperative Education Program (COOP)	Undergraduate	Navy	Navy Oce
Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) Program	Undergraduate	Navy	Office of
Cooperative Education Program (COOP)	Undergraduate	Air Force	Headqua
Cooperative Education Program (COOP)	Undergraduate	Defense Mapping Agency	Defense
Federal Junior Fellowship Program (FJFP)	Undergraduate	Defense Mapping Agency	Defense
Historical Black College and University (HBCU) Program	Undergraduate	Defense Mapping Agency	Defense
Cooperative Education Program (COOP)	Undergraduate	National Security Agency	National
Undergraduate Training Program	Undergraduate	National Security Agency	National
Summer Employment Program	Undergraduate	National Security Agency	National
Computer Operator Associateship Program	Undergraduate	National Security Agency	National
Grow Your Own Program	Undergraduate	National Security Agency	National
Coastal Engineering Education Program (CEEP)	Graduate	Army	Army Cor
Water Resources Planning Associate (PA) Program	Graduate	Army	Army Cor
Graduate Fellowship in Water Resources and Environmental Law (WREL)	Graduate	Army	Army Cor
Mission Related Graduate Program (MRGP)	Graduate	Army	Army Cor
Waterways Experimental Station (WES) Graduate Institute	Graduate	Army	Army Cor
Operations Research System Analysis (ORSA) Fellowship Program	Graduate	Army	Army Ma
Operations Research System Analysis (ORSA) Advanced Study Program	Graduate	Army	Army Ma
National Defense Science and Engineering Graduate (NDSEG) Fellowship Program	Graduate	Army	Army Res
Science and Technology Fellowship Program	Graduate	Army	Army Res
Graduate Study Award Program (GSAP)	Graduate	Navy	Naval Air
Engineer and Science Development Program	Graduate	Navy	Naval Air
New Professional Development Program	Graduate	Navy	Naval Co
Graduate Academic Program	Graduate	Navy	Naval Oc
Long Term Training	Graduate	Navy	Naval Oc
Instructional TV Program	Graduate	Navy	Naval Oc
Instructional Satellite Program	Graduate	Navy	Naval Oc
Advanced Graduate Research Program	Graduate	Navy	Naval Re
Edison Memorial Graduate Training Program	Graduate	Navy	Naval Re
Select Graduate Program	Graduate	Navy	Naval Re
Engineering Long Term Training	Graduate	Navy	Naval Se

[a] Some programs permit participation at more than one academic level; the level shown is the predominant use.
[b] Office or organization administering the program when different from the reporting unit.

Reporting unit	Administering office[b]
Naval Research Laboratory	
Naval Research Laboratory	
Naval Sea Systems Command	
Navy Oceanographic & Atmospheric Research Laboratory	
Office of Naval Research	
Headquarters U.S. Air Force	Director of Civilian Personnel (AF/DPC)
Defense Mapping Agency	
Defense Mapping Agency	
Defense Mapping Agency	Jackson State University
National Security Agency	
National Security Agency	
National Security Agency	
National Security Agency	
National Security Agency	
Army Corps of Engineers	
Army Corps of Engineers	
Army Corps of Engineers	Waterways Experimental Station Graduate Institution
Army Corps of Engineers	
Army Corps of Engineers	
Army Material Command	
Army Material Command	
Army Research Office	Battelle
Army Research Office	
Naval Air Development Center	
Naval Air Systems Command	
Naval Coastal Systems Command	Naval Coastal Systems Center
Naval Ocean Systems Center	
Naval Ocean Systems Center	
Naval Ocean Systems Center	
Naval Ocean Systems Center	
Naval Research Laboratory	
Naval Research Laboratory	
Naval Research Laboratory	
Naval Sea Command	

Table A-1.
DoD Science and Engineering Intervention Programs (Continued)

Program	Education level[a]	Military Service/ Defense Agency	
Naval Sea Systems Command Institute	Graduate	Navy	Naval Se
Long Term Training Program	Graduate	Navy	Naval W
California State University Chico External Degree	Graduate	Navy	Naval W
California State University Northridge External Degree	Graduate	Navy	Naval W
Graduate Fellowship Program (GFP)	Graduate	Navy	Office of
National Defense Science and Engineering Graduate (NDSEG) Fellowship Program	Graduate	Navy	Office of
Engineering and Acquisition Management Program	Graduate	Navy	Space a
Civilian Scientists and Engineers Career Program	Graduate	Air Force	Headqua
PALACE KNIGHTS Intern Program for Scientists and Engineers	Graduate	Air Force	Headqua
PALACE ACQUIRE Intern Program for Scientists and Engineers	Graduate	Air Force	Headqua
Research in Aero Propulsion Technology (AFRAPT)	Graduate	Air Force	Office of
Advanced Thermionic Research Program (ATRP)	Graduate	Air Force	Office of
Laboratory Graduate Fellowship Program (LGTP)	Graduate	Air Force	Office of
Graduate Student Research Program (GSRP)	Graduate	Air Force	Office of
National Defense Science and Engineering Graduate (NDSEG) Fellowship Program	Graduate	Air Force	Office of
Joint Services Electronics Fellowship Program	Graduate	Air Force	Office of
National Defense Science and Engineering Graduate (NDSEG) Fellowship Program	Graduate	Defense Advanced Research Project Agency	Defense
Full-Time Study Program	Graduate	Defense Intelligence Agency	Defense
After Hours Tuition Support	Graduate	Defense Intelligence Agency	Defense
DCI Exceptional Analyst Program	Graduate	Defense Intelligence Agency	Defense
Long Term Full-Time Training Program	Graduate	Defense Mapping Agency	Defense
Civilian Science and Training Program	Graduate	Defense Nuclear Agency	Defense
Thesis Research for Graduate Study Program	Graduate	Defense Nuclear Agency	Defense
Graduate Study Program	Graduate	Defense Nuclear Agency	Defense
Internal Training	Graduate	National Security Agency	National
Advanced Study Program	Graduate	National Security Agency	National
After Hours College Program	Graduate	National Security Agency	National
Directed Fellowship/Scholar Program	Graduate	National Security Agency	National
Fellowship and Scholarship Program	Graduate	National Security Agency	National
Research Assistantships-General	Graduate	All	Office of

[a] Some programs permit participation at more than one academic level; the level shown is the predominant use.

[b] Office or organization administering the program when different from the reporting unit.

Reporting unit	Administering office[b]
Naval Sea Systems Command	
Naval Weapons Center	
Naval Weapons Center	
Naval Weapons Center	
Office of Naval Research	Battelle
Office of Naval Research	Battelle
Space and Naval Warfare Systems Command	
Headquarters U.S. Air Force	Air Force Civilian Personnel Management Center
Headquarters U.S. Air Force	Air Force Civilian Personnel Management Center
Headquarters U.S. Air Force	Air Force Civilian Personnel Management Center
Office of Scientific Research	
Office of Scientific Research	
Office of Scientific Research	Southeastern Center for Electrical Engineering Education
Office of Scientific Research	Research and Development Laboratories, Inc.
Office of Scientific Research	Battelle
Office of Scientific Research	
Defense Advanced Research Project Agency	Battelle
Defense Intelligence Agency	
Defense Intelligence Agency	
Defense Intelligence Agency	
Defense Mapping Agency	
Defense Nuclear Agency	
Defense Nuclear Agency	
Defense Nuclear Agency	
National Security Agency	National Crypto School
National Security Agency	
National Security Agency	
National Security Agency	
National Security Agency	National Crypto School
Office of the Secretary of Defense	

Table A-1.
DoD Science and Engineering Intervention Programs (Continued)

Program	Education level[a]	Military Service/ Defense Agency	
Summer Associateship Program for High School Science and Mathematics Faculty	PD/Faculty	Army	Army
National Research Council (NRC) Postdoctoral Research Associateships	PD/Faculty	Army	Army
Laboratory Research Cooperative Program (LRCP)	PD/Faculty	Army	Army
Summer Faculty Research and Engineer Program (SFREP)	PD/Faculty	Army	Army
University Research Institute (URI) Fellowship	PD/Faculty	Army	Army
National Research Council (NRC) Postdoctoral Research Associateship	PD/Faculty	Navy	Naval
General Laboratory Science Interchange Program	PD/Faculty	Navy	Naval
National Research Council (NRC) Postdoctoral Research Associateships	PD/Faculty	Navy	Naval
Jackson State Research and Education Program	PD/Faculty	Navy	Naval
Summer Faculty Program	PD/Faculty	Navy	Naval
Research Associateship Program	PD/Faculty	Navy	Naval
National Research Council (NRC) Postdoctoral Research Associateships	PD/Faculty	Navy	Navy
Women Science Scholars (WSS)	PD/Faculty	Navy	Office
Young Investigator Program (YIP)	PD/Faculty	Navy	Office
Summer Faculty Research Program	PD/Faculty	Navy	Office
Office of Naval Technology (ONT) Postdoctoral Program	PD/Faculty	Navy	Office
National Research Council (NRC) Postdoctoral Research Associateships	PD/Faculty	Air Force	Office
University Resident Research Program (URRP)	PD/Faculty	Air Force	Office
Summer Faculty Research Program (SFRP)	PD/Faculty	Air Force	Office
Research Initiation Program (RIP)	PD/Faculty	Air Force	Office
National Research Council (NRC) Postdoctoral Research Associateships	PD/Faculty	Defense Nuclear Agency	Defen
Summer College Outreach Program (SCORE)	PD/Faculty	National Security Agency	Natior
College Recruitment Program	Other[c]	Navy	Naval
Adopt-a-College (HBCU/MI)	Other	Navy	Naval
Recruitment-General	Other	Navy	Naval
Professional Recruitment Program	Other	Navy	Naval
Accelerated Promotion Program	Other	Navy	Naval
Recruitment Program	Other	Navy	Naval
Developmental Training Program	Other	Navy	Naval
Engineering and Acquisition Management Module HRD Program	Other	Navy	Space

Note: PD = Post doctorate

[a] Some programs permit participation at more than one academic level; the level shown is the predominant use.

[b] Office or organization administering the program when different from the reporting unit.

[c] Program objectives are different than science and engineering education, such as recruiting, retention, or management.

Reporting unit	Administering office[b]
Army Research Office	Battelle
Army Research Office	National Research Council
Army Research Office	Battelle
Army Research Office	Battelle
Army Research Office	
Naval Ocean Systems Center	National Research Council
Naval Research Laboratory	
Naval Research Laboratory	National Research Council
Naval Oceanographic and Atmospheric Research Lab	Jackson State University
Naval Oceanographic and Atmospheric Research Lab	
Naval Oceanographic and Atmospheric Research Lab	
Navy Post-Graduate School	National Research Council
Office of Naval Research	Bunting Institute, Radcliff College
Office of Naval Research	
Office of Naval Research	American Society for Engineering Education
Office of Naval Technology	American Society for Engineering Education
Office of Scientific Research	National Research Council
Office of Scientific Research	
Office of Scientific Research	Research and Development Laboratories, Inc.
Office of Scientific Research	Research and Development Laboratories, Inc.
Defense Nuclear Agency	National Research Council
National Security Agency	
Naval Air Development Center	
Naval Air Development Center	
Naval Air Development Center	
Naval Electronics Systems Engineering Activity	
Naval Electronics Systems Engineering Activity	
Naval Facilities Engineering Command	
Naval Ocean Systems Center	
Space and Naval Warfare Systems Command	

Table A-1.
DoD Science and Engineering Intervention Programs (Continued)

Program	Education level[a]	Military Service/ Defense Agency	
Upward Mobility Program	Other[c]	Defense Mapping Agency	Defe
Tuition Assistance Program	Other	Defense Mapping Agency	Defe
Executive Leadership Program	Other	Defense Mapping Agency	Defe
Conferences and Job Fairs	Other	Defense Mapping Agency	Defe
Advertising and Publicity Program	Other	Defense Mapping Agency	Defe
College Recruitment Program	Other	Defense Mapping Agency	Defe
Professional Program	Other	National Security Agency	Nati

[a] Some programs permit participation at more than one academic level; the level shown is the predominant use.

[b] Office or organization administering the program when different from the reporting unit.

[c] Program objectives are different than science and engineering education, and or recruiting, or management.

Reporting unit	Administering office[b]
Defense Mapping Agency	
Defense Mapping Agency	
Defense Mapping Agency	
Defense Mapping Agency	
Defense Mapping Agency	
Defense Mapping Agency	
National Security Agency	

APPENDIX B

Selected DoD Science and Engineering Intervention Programs

Selected DoD Science and Engineering Intervention Programs

This appendix contains detailed descriptions of 32 DoD science and engineering intervention programs. They were selected by LMI for detailed evaluation in this study and are presented in four annexes:

- Annex B-1 — Pre-College Programs
- Annex B-2 — Undergraduate Programs
- Annex B-3 — Graduate Programs
- Annex B-4 — Postdoctoral/faculty Programs

The criteria used to select these programs from the 136 reported science and engineering intervention programs is contained in Chapter 4. The complete list of 136 programs by program name, education level, military service/defense agency, reporting unit, and administering office is contained in Appendix A.

The 32 science and engineering intervention programs are distributed as follows:

◆ Pre-college programs	–	10
◆ Undergraduate programs	–	7
◆ Graduate programs	–	6
◆ Postdoctoral/faculty programs	–	9
Total	–	32

As discussed in Chapter 4, some of these programs are designed to permit participation at more than one level: e.g., both pre-college and undergraduate, or undergraduate and graduate. Our categorization of the programs was based upon the predominant use.

ANNEX B-1

Pre-College Programs

Pre-College Programs

SCIENCE AND ENGINEERING FAIRS

Military Service/Defense Agency

Army

Reporting Unit

Army Research Office

Administering Office

Science Service, Inc., Washington, D.C. (contractor)

Contact

Mr. Donald Rollins, Army Research Office, (919) 549-0641

Objective

To stimulate and encourage the future technical development of our nation's youth.

Description

The program is under the direction of local academic or civic groups. Science fairs annually attract over 100,000 high school students with a demonstrated interest in science, engineering, and mathematics. Students bring their research projects to the fairs for evaluation and recognition by educational, industrial, governmental, and military groups.

Over 350 local, state, and regional fairs are held throughout the United States, Puerto Rico, Guam, and the Virgin Islands. Students winning at the regional fairs also have an opportunity to compete at the national level. Science Service, Inc. determines the site of the national fair.

Science Service, Inc. sets the guidelines for all competitions. The Army is one of 11 organizations that give awards at the regional fairs. Science Service, Inc. awards four prizes in each category at all regional fairs and at the national fair. Approximately 60 different organizations award prizes at the national fair. The top two places in the national fair are awarded free trips to the Nobel Prize Ceremony in Norway.

Cost

The Army spent $50,000 in FY89 to participate in more than 350 science fairs nationwide. The program is funded annually.

Legal Authority

The science and engineering fairs are funded by a grant to the contractor, who pays the costs, including some of the participant's expenses. This is a science and engineering interest type program. There is no employment or research and development accomplished. Specific authorizing statutes have not been found (see Appendix D, pages 7 and 8).

Evaluation

This program stimulates interest in science and engineering and establishes good will for the Army. The Army does not attempt to follow up these students (especially those winning prizes) to make them aware of opportunities for getting into DoD high school apprenticeship programs, summer work programs, or later into the college Cooperative Education or Reserve Office Training Corps programs.

Overall Assessment

Although the Army spends relatively little money on this program, it should formulate follow-up procedures for participants, especially prize winners to recruit them into other DoD scholarship or work-study programs.

The military research and development organizations have a continuing interest, along with other U.S. institutions, in supporting programs encouraging increased study of science and engineering by high school students. Within DoD, the question is how much money should be spent on these programs as opposed to other intervention programs that more directly support military research and development and employment.

JUNIOR SCIENCE AND HUMANITIES SYMPOSIUM

Military Service/Defense Agency

Army

Reporting Unit

Army Research Office

Administering Office

Academy of Applied Science, Concord, N. H. (contractor)

Contact

Mr. Donald Rollins, Army Research Office, (919) 549-0641

Objective

This symposium has several objectives:

- To promote research and experimentation in the sciences, mathematics and engineering at the high-school level.
- To recognize the significance of research in human affairs, and the importance of humane and ethical principles in the applications of research results.
- To search out talented youth and their teachers, recognize their accomplishments at symposia, and encourage their continued interest and participation in the sciences, mathematics, and engineering.
- To expand the horizons of research-oriented students by exposing them to opportunities in the academic, industrial, and governmental communities.
- To enlarge the number of future adults capable of conducting research and development.

Description

The Junior Science and Humanities Symposium (JSHS) encourages high school students studying science and mathematics to present papers describing research they have accomplished before other students and teachers. It consists of 2-or-3 day meetings of high-school students and teachers who have interest in science, engineering, and mathematics, and the relationships of those fields to the humanities. The symposia are attended by several thousand high school students and science teachers in a ratio of approximately four to one. A typical symposium includes:

- Several papers given by students in which they describe research they accomplished while still in high school
- On-site observations of research performed by professionals, who demonstrate methods and explain their goals
- Discussions, by scientists, of current research that is of general interest and potentially important
- Talks emphasizing the importance of a scientist to be well rounded, both educationally and culturally
- A presentation by a famous research scientist
- Conferences in which students and teachers pose questions on the processes of research and the pursuit of scientific research as a career.

The Army Research Office started the JSHS program in 1958 with the intention of developing a national program. It exists in every state except Alaska and Hawaii. Approximately 7,500 students participated in the program in 1990, with more than 175,000 participating since 1958.

The JSHS consists of 46 regional symposia, each 2-to-3 days in length. Students present an oral and written description of their research projects. Five students are selected from each region to attend the national symposia, where the superior projects are selected. Students cannot bring their exhibit or invention to a symposium, but must orally describe the project and provide a written paper supporting it. In addition to presenting their projects the students meet in smaller groups with teachers to discuss areas of mutual interest, much like the format of modern professional meetings.

Cost

The program costs $870,000 per year or approximately $116 per student. The funds pay for the management of the symposia, transportation, room and board for the students, and for awards. The teachers attend at their own expense.

Legal Authority

The JSHS is funded by a grant to the Academy of Applied Science, which pays for the symposia and the expenses of the participants. This is a science and engineering interest type program. There is no employment or research and development accomplished. These programs are funded annually on a continuing basis. Specific authorizing statutes have not been found (see Appendix D, pages 7 and 8).

Evaluation

This program provides extensive one-on-one contact between students and researchers, some of which continues over a long period. Unlike the Science Fairs, during which students only present a project for judging, the JSHS has numerous activities taking place concurrently.

Neither the Navy nor the Air Force participates in this program, even though the Army establishes contacts with a large number of future scientists and engineers. We believe that the students participating in the JSHS should be encouraged to participate in other DoD intervention programs, including high school apprenticeship, summer work, as well as the Cooperative Education Program and intern programs following college graduation.

Overall Assessment

The program has significant merit and should be considered for expansion, particularly to include the other Military Services.

UNINITIATES INTRODUCTION TO ENGINEERING

Military Service/Defense Agency

Army

Reporting Unit

Army Research Office

Administering Office

Junior Engineering Technical Society, Alexandria, Va. (contractor)

Contact

Mr. Donald Rollins, Army Research Office, (919) 549-0641

Objective

To enhance the preparation of more minority students for entry into, and graduation from, schools of engineering.

Description

The Uninitiates Introduction to Engineering (UNITE) program consists of universities and colleges providing remedial mathematics instruction to minority students during 4-week summer sessions for the purpose of interesting them in the study of science or engineering in college.

The Army Research Office started the UNITE program sometime before 1980. Since then, up to 10 universities and colleges throughout the United State have participated, and as many as 680 students have attended during a particular summer. Each university or college would provide at least four weeks of in-classroom academic instruction, primarily in trigonometry and precalculus. They also offered instruction in computer fundamentals, physics or chemistry and some form of communication skills.

During the past three to four years, however, the program has undergone an evaluation which has reduced the numbers of participating universities and students.

Currently there are four universities and approximately 250 students participating, as shown below:

University	Summer 1989	Summer 1990
Delaware	40	55
Detroit	34	60
New Mexico	125	113
Long Beach	none	30

Each school establishes its own selection criteria. The minimum requirements are generally a "B" in all high school academic subjects (college-prep), appropriate letters of reference, and some form of demonstrated interest in a mathematics-based curricula. Some schools also require preliminary college board scores if available. The program is open to all disadvantaged students, regardless of racial/ethnic origin in high school grades 9 through 12,

and may participate for more than 1 year. Approximately 98 percent of the students are minorities, including large numbers of Hispanics and American Indians. The program includes a provision for each school to follow-up with contacts with the students during the high school academic year.

Other programs of a similar nature are offered by colleges and universities across the country. These programs are often called Minority Introduction to Engineering (MITE). During the early part of the Army program, the contractor, the Junior Engineering Technical Society (JETS), also supported the MITE programs. However, it was believed that the MITE programs to be unfocused and not containing enough academic-based mathematics education. As a result, it was decided to concentrate on a few universities to assure that the program was rigorous and productive.

Cost

The program costs $150,000 per year (up from $100,000 a couple of years ago). For 250 students, this equates to approximately $600 per student.

Legal Authority

The UNITE is funded by a grant to the JETS, which then pays the participant schools a stipend. This is a science and engineering interest type program. There is no employment or research and development accomplished. These programs are funded annually on a continuing basis. Specific authorizing statutes have not been found (see Appendix D, pages 7 and 8).

Evaluation

As part of our evaluation of this program, we asked the project manager for the Army Research Office whether this program should be expanded. The project manager gave a qualified yes. He then suggested it be done very slowly and carefully. We also asked whether he had any evidence concerning the program's success. He responded that few of the participants completed a baccalaureate degree in science or engineering.

Overall Assessment

Although the program's objectives are lofty, they have not yet been translated into measurable benefits. The instability of the program over the past several years appears to be a factor in its lack of success.

Its contribution to employing the science and engineering pool appears negligible. There are other minority students in the population that have better high school preparation and would benefit in greater measure from this type of program.

Research and Engineering Apprenticeship Program

Military Service/Defense Agency

Army

Reporting Unit

Army Research Office

Administering Office

Academy of Applied Science, Concord, N.H. (contractor)

Contact

Mr. Donald Rollins, Army Research Office, (919) 549-0641

Objective

To provide a cooperative education (work/study) program that gives hands-on experience to high school students who may enter and complete basic education in science and engineering.

Description

This program gives academically capable and socially and economically disadvantaged students an 8-week summer work/study experience with pay in a university laboratory.

The Research and Engineering Apprenticeship Program (REAP) provides a summer work/study experience that assists students to remain in high school, provide new insights into science and engineering careers, and to encourage them to enter a college program of science and engineering education.

The program started in 1980 with 55 participants; and has since grown to 116 participants at 55 universities in 1990. Each student is assigned to a university professor who serves as the student's mentor. Some mentors have two or more students, but most of them have only one.

All high-school students are eligible for the program, however most of the participants are juniors and seniors. Rising college freshmen also are eligible. Once accepted into the program, the student may remain in the program until they start to college.

Students work with their assigned mentor in a university laboratory during the summer for a period of at least 8 weeks. They also are encouraged to develop a continuing relationship throughout high school and beyond. In 1989, the distribution of participants was: 20 high school freshmen, 14 sophomores, 53 juniors, and 28 seniors.

Cost

The program costs $250,000 per year. The cost per student is nominally $2,500, which is typically split between the mentor and the student. In some cases, the mentor forgoes any payment and applies it toward an additional student. No money goes to the universities. Some, in fact obtain funds from other sources to support more students.

Legal Authority

REAP is funded by a grant to the Academy of Applied Science, which pays the participants a stipend. Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities. Title 5 U.S.C., Chapter 41, establishes guidelines for training federal employees. Those statutes, along with DoD Instruction 3218.1, DoD Science and Apprenticeship Program for High School Students, July, 1981 provides specific authority and procedures.

Evaluation

This program is based on the premise that many socially and economically disadvantaged students, who are doing well in high school and are capable of pursuing a course in science or engineering in college, need nurturing and exposure to the careers of scientists and engineers. These students do not need remedial education. This program attracts minority as well as white disadvantaged.

Neither the Navy nor the Air Force participate in this program or support similar programs. Many REAP students could be encouraged to participate in other DoD intervention programs, including high school apprenticeship

programs, summer work programs, and cooperative education, as well as intern programs following graduation from college.

Overall Assessment

The program has significant merit and should be considered for expansion, not only within the Army, but the in other Military Services as well.

MINORITIES IN ENGINEERING PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Naval Air Development Center

Administering Office

Naval Air Development Center

Contact

Ms. Lois Savage, Naval Air Development Center, (215) 441-3061/2

Objective

To interest local high school students in science and engineering professions and in the Naval Air Development Center (NADC) as a potential employer.

Description

This program identifies and assists minority high-school students in learning more about the research and development that takes place at the Naval Air Development Center, Warminster, Pennsylvania.

Through teachers and counselors in nearby high schools, NADC identifies students who have at least a 2.5 grade-point average and are interested in science and engineering. NADC then invites those students to 8 to 12 2-hour

sessions at NADC during the academic year. At those sessions at NADC personnel describe their work and present introductory classes (sessions) on engineering, computer programming, career planning, electronics and project accomplishment. The 2-hour sessions are held during the day approximately every two weeks. As a result, therefore, students must be excused from class in order to attend, which sometimes causes difficulties in coordinating the sessions with the schools. Parents are invited to an initial reception and for a graduation ceremony at the end of the academic year.

The NADC are staff apparently has considerable enthusiasm for the program, however, they have difficulty finding the students, because they need to work through the school bureaucracy. They have found it essential to have contact with a good teacher in the high school to help identify and encourage the students. The participation of the parents is also essential.

In addition to helping minority students prepare for and complete college in science and engineering, NADC's ultimate objective is to identify and hire future employees.

Cost

The program cost $3,000 in FY89 for 25 students, or about $120 per student.

Legal Authority

The MEP is funded from in-house funds. This is a science and engineering interest type program. There is no employment or research and development accomplished. These programs are funded annually on a continuing basis. Specific authorizing statutes have not been found (see Appendix D, pages 7 and 8).

Evaluation

This program appears to be managed and conducted by very committed personnel, but it suffers from lack of continuity and funding. We suggest that NADC examine the REAP program sponsored by the Army (ARO), through the Academy of Applied Sciences, as an example of a summer program with winter continuity along the lines of a high school apprenticeship program. We also suggest they get in touch with the Office of Naval Research, who sponsors the SEAP program through George Washington University.

This program should be expanded. It should be offered in the summer as a high school apprenticeship program with pay, using the sessions at the laboratories during the academic year to assure continuity with the students.

Overall Assessment

The program has significant promise but it needs to be focused on paid summer apprenticeships.

NAVY HIGH SCHOOL APPRENTICESHIP PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Research

Administering Office

Office of Naval Research

Contact

Ms. Debora Hughes, Office of Naval Research, (703) 696-4108

Objective

To interest high school students in studying science and engineering in college, and to acquaint them with state-of-the-art laboratory techniques through hands-on experience.

Description

This program provides academically capable high school students with eight to ten weeks of paid summer work/study experience in university laboratories. It is aimed to minorities and women but others may participate.

The program uses principal investigators, who are working on existing Navy research contracts, to reach high school students that are both academically able, but under-represented in science and engineering. The investigators attract and manage one or more interested high school students. The Navy funds this program by providing additional grant dollars to existing Navy research contracts.

The program started in 1981 with a few participants and has grown to 90 participants in 1990. All high school students are eligible, including rising college freshmen. Once accepted into the program, students are eligible to remain until they start college.

Students work with their assigned mentor in the respective laboratory for a period of at least 8 to 10 weeks during the summer, for 35 hours per week. Each student receives a stipend from the university, so he or she is not on the government payroll.

The investigators keep in touch with their students during the winter and in some cases permit the students to work a few hours each week. These arrangements are made between the investigator and the student, without any Navy participation or support.

Cost

The program cost $180,000 in FY89 for 90 students, or about $2,000 per student.

Legal Authority

The program is funded by grants to universities, which in turn pay the participants a stipend. Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities. Title 5 U.S.C., Chapter 41, establishes guidelines for training Federal employees. These statutes, along with DoD Instruction 3218.1, DoD Science and Apprenticeship Program for High School Students, July 1981, provide specific authority and procedures.

Evaluation

The Office of Naval Research strongly believes that this program is much better than other precollege programs that provide only superficial exposure to research activities; the hands-on experience is particularly important. The program has low overhead, and all funds are applied to student stipends. It also appears to be ably managed and successful.

Overall Assessment

The program has significant merit and should be considered for expansion.

SCIENCE AND ENGINEERING APPRENTICESHIP PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Research

Administering Office

George Washington University, Washington, D.C. (contractor)

Contact

Ms. Debra Hughes, Office of Naval Research, (703) 696-4108

Objective

To interest high school students in studying science and engineering in college.

Description

This program provides academically outstanding students an 8-week summer work/study experience with pay in Army and Navy laboratories; it also includes some high school teachers to aid in administering the program.

The program seeks to attract outstanding high school students, principally from the Washington, D.C. area, to perform scientific research in Army and Navy laboratories for 8 weeks in the summer. George Washington University administers the program at 23 laboratories.

Started in 1979, the program has grown to include 671 participants in 1989. Each participant is assigned to a laboratory researcher who serves as the student's mentor. At 20 of the larger laboratories, high school teachers help to administrator the programs; they also obtain hands-on experience which they carry back to the classrooms.

All high school students are eligible, including rising college freshmen. Once accepted into the program, students are eligible to remain in the program until they start to college.

Each student receives a stipend from George Washington University, not from the government. Mentors may have more than one student, and have expressed support for the program – they request continuation and return of previous students.

Cost

The program cost $1.2 million in FY89 for 671 students, (or about $1,800 per student). The laboratory commanders often augment program funding from laboratory sources.

Legal Authority

The SEAP is funded by a grant to George Washington University, which then pays the participants a stipend. Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities. Title 5 U.S.C., Chapter 41, establishes guidelines for training Federal employees. Those statutes, along with DoD Instruction 3218.1, DoD Science and Apprenticeship Program for High School Students, July 1981, provide specific authority and procedures.

Evaluation

This program appears to be ably managed and is very successful. It also could be linked to other programs, such as the Cooperative Education Program and Government intern programs following graduation from college.

Overall Assessment

The program has significant merit and should be considered for expansion.

NAVY SCIENCE AWARDS PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Research

Administering Office

Science Services Inc., Washington, D.C. (contractor)

Contact

Ms. Barbara Thurman, Office of Naval Research, (703) 696-4108

Objective

To encourage high school students to consider careers in science and engineering.

Description

This program awards prizes at science fairs. It encourages high school students to develop an interest in science and engineering by rewarding scientific achievement demonstrated at local and national science fairs.

At local fairs, the Navy and Marine Corps reservists present certificates for first, second, and third places; first place winners also receive a leather attaché case.

The Navy awards three $8,000 scholarships and two $3,000 scholarships to national winners. It also awards 25 trips to visit San Diego Naval Research and Development facilities.

At the annual International Science and Engineering Fair sponsored by Science Service, Inc., the Navy awards four $10,000 scholarships plus five all-expense-paid trips to London, England, to attend the London International Youth Science Fortnight.

Cost

The program cost $200,000 in FY89 for participation in about 400 science fairs nationwide.

Legal Authority

The program is funded by a grant to Science Service, Inc., which in turn pays all the costs. This is a science and engineering interest type program. There is no employment or research and development accomplished. These programs are funded annually on a continuing basis. Specific authorizing statutes have not been found (see Appendix D, pages 7 and 8); although SECNAVINST 5720.19F, 9 October 1986 provides Department of Navy authority and implementing instructions.

Evaluation

This program aids in stimulating interest in science and engineering as a career and in building good will for the Navy and Marine Corps.

The Office of Naval Research is currently reviewing the program to determine if it could reallocate some of the travel funds to more scholarships. It has also expressed interest in upgrading the quality of the Navy and Marine Corps judges.

The Navy makes no attempt to follow up those students that either win scholarships or come close to winning with opportunities for getting into high school apprenticeship programs or later into the college Cooperative Education Program or Naval Reserve Officer Training Corps.

Overall Assessment

The program has significant merit, but the Navy need to assure that funds being expended have some payback. Better record keeping of participants and follow-up would be very helpful. The program review by the Office of Naval Research is very timely.

AIR FORCE HIGH SCHOOL APPRENTICESHIP PROGRAM

Military Service/Defense Agency

Air Force

Reporting Unit

Office of Scientific Research

Administering Office

Research and Development Laboratories, Inc., Culver City, Calif.

Contact

Lt. Col. Claude Cavender, Office of Scientific Research, (202) 767-4970

Objective

To stimulate the interest of high school students in pursuing careers in science or engineering by allowing them to work on technical projects in Air Force laboratories.

Description

This program provides academically outstanding students an 8-week summer work/study experience with pay in an Air Force laboratory, and interests them in studying science and engineering in college. The students are provided a work/study experience that assists them financially to remain in high school, to provide new insights into science and engineering careers, and to encourage them to enter a college program of science or engineering education.

Tailored after existing Army programs, the Air Force apprenticeship program was started in 1986 with 42 students; it had 133 students in 1990. Each student is assigned to a laboratory researcher, who serves as the student's mentor. They work with their assigned mentor in one of 15 Air Force laboratories.

All high school students are eligible, including rising college freshmen. Once accepted into the program, students may remain until they start college. Each student is an employee of the contractor, not the government.

Cost

The program cost $180,000 in FY89 for 103 students, or about $1,750 per student. The laboratory commanders believe this program to be so effective that they often augment the Office of Scientific Research funding with some additional money from laboratory sources.

Legal Authority

The Air Force High School Apprenticeship Program is funded by a grant to Research and Development Laboratories, Inc., which pays all participants a stipend. Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities, while Title 5 U.S.C., Chapter 41, establishes guidelines for training federal employees. Those statutes, together with DoD Instruction 3218.1, DoD Science and Apprenticeship Program for High School Students, July 1981, provide specific authority and procedures.

Evaluation

This program was started somewhat later than the Army and Navy programs of similar focus. However, it has grown rapidly at the request of the mentors and laboratory management. It appears to be ably managed and to achieve its stated objectives. Nevertheless, the Air Force does not have formal follow-up procedures to encourage participation in more advanced programs, such as summer employment or the Cooperative Education Program.

Overall Assessment

The program has significant merit and should be considered for expansion.

Texas Pre-Freshman Engineering

Military Service/Defense Agency

Defense Mapping Agency

Reporting Unit

Defense Mapping Agency

Administering Office

University of Texas, San Antonio, Tex. (contractor)

Contact

Dr. Manuel P. Berriozabel (University of Texas), (512) 691-4496/5530

Objective

To identify and encourage promising middle and high school students with an interest in science and engineering to pursue careers in those fields.

Description

Each summer the University of Texas offers academically able minority high school students an opportunity to receive 8- to 10-weeks of instruction in science and engineering subjects at 14 locations throughout the state. Only students with a "B" average are accepted.

The subjects covered include mathematics, introduction to engineering, computer science, probability, physics, and problem solving. The students can progress to more advanced course work each summer, up to three summers. All courses are centrally planned but locally administered.

Since 1979, when the program started, approximately 79 percent of the students have been minority. The University of Texas estimates that 53 percent of the students attending the 1990 sessions qualified for school lunch programs, which is fairly representative of the areas were the instruction was offered. A 1990 survey showed that 87 percent of previous participants were attending college and 57 percent were majoring in science or engineering.

Both the Air Force and Navy send recent academy graduates, who are awaiting assignments, to serve as instructors. They in turn provide excellent instruction and outstanding role models for the students.

School counselors, teachers, and high school board members encourage students to attend this program. At some locations, students are turned away because there of a shortage of teachers. The program is viewed locally as a very prestigious program.

The program director, Dr. Manuel Berriozabel, will complete the preparation of curriculum materials by 1992, so they could be used by other programs.

Some of the characteristics of this program include:

- Select students who are high achievers.
- Special effort to recruit women and minority students.
- High but reasonable expectations from students.
- Conducted in a college environment.
- An academic enrichment program stressing topics, and subjects, that are important for success in high school and college.
- Well organized and highly structured program.
- Involvement of parents, counselors, and teachers.
- Development and maintenance of external linkages.
- Extensive tracking and follow-up.
- Significant involvement of minority professionals and staff members.

Cost

The Defense Mapping Agency provided $37,000 to this program in FY89, which pays for the counselors and teachers. The total cost of the program in 1989 was $1,776,000, for 1,096 students. Most of the funding for this program is from contributions. Texas does not contribute any educational funds.

Legal Authority

The Defense Mapping Agency contribution is provided as a grant. This is a science and engineering interest type program. There is no employment or research and development accomplished. These programs are funded annually on a continuing basis. Specific authorizing statutes have not been found (see Appendix D, pages 7 and 8).

Evaluation

This program appears to be managed and conducted by very committed and capable personnel. It should serve for as a model for other programs. It is an academic program, not a hands-on, laboratory-based program. This program provides a valid alternative to a lab-based program by providing a fundamental academic foundation for academically capable, but disadvantaged youth. It can still be improved, however. The funding is not very reliable, depending

primarily on contributions. It also does not have any formal procedures for maintaining ties with the students during the subsequent academic term.

Overall Assessment

The program appears very successful. It is a professional, rigorous program that has demonstrated its viability. The program could be expanded to serve as a model nation-wide.

ANNEX B-2

Undergraduate Programs

Undergraduate Programs

Science and Engineering Cooperative Program

Military Service/Defense Agency

Army

Reporting Unit

Headquarters, U.S. Army

Administering Office

U.S. Army Personnel Command, in cooperation with U.S. Army Cadet Command

Contact

Ms. Penny Berardelli, U.S. Army Personnel Command, (703) 325-4462; Major Barry Cave, U.S. Army Cadet Command, (804) 727-3909/2873.

Objective

To provide new Reserve Component Army officers with science and engineering backgrounds, and to recruit new scientists and engineers into the Army's laboratory workforce.

Description

This program assists students to complete baccalaureate degrees in science and engineering while alternating work at Army laboratories in the summer with their studies. Students participate in the Army Reserve Officer Training Corps (ROTC) program while at school, accepting a commission in either the Army National Guard or U.S. Army Reserve at graduation with an eight-year military service obligation. All participants are required to maintain membership in a Reserve Component while a full-time federal civilian employee in a Government laboratory.

Each year, the Army trains more personnel through its ROTC program than can be brought on active duty. Those extra ROTC students are then commissioned into the Army National Guard or U.S. Army Reserve, but do not have an active duty commitment. Instead, they are available to work as civilian employees in the Army.

The program provides students in science and engineering curricula with up to $5,000 per year in tuition assistance in addition to a monthly senior ROTC stipend. It also provides part-time employment at facilities at the GS-2 to GS-5 wage level. In return, the student signs a commitment to work for the government for a designated period of time, (depending on the length of curriculum followed) following graduation. This program was initiated in 1984 on a trail basis. In 1990, the Army had 130 students enrolled. If the Army cannot offer the graduate a suitable job at the time of graduation and commissioning, the participant retains only the eight-year service obligation in the Army National Guard or U.S. Army Reserve.

Cost

This program cost $1.3 million in FY89 for 147 students, or about $9,000 per student.

Legal Authority

Title 5 U.S.C. provides authority for training of government employees. These students are hired into government service just like a regular Cooperative Education Program student, under Schedule B in accordance with 5 CFR 213.3202(a) and FPM 308. This regulation also permits conversion of the Schedule B appointment to competitive service (career or career-conditional) at any time within a 120-day period following satisfactory completion of a career-related, work study program.

Evaluation

This is a novel program that targets a population of science and engineering students that otherwise might not become Federal civilian employees after graduation. It appears to be quite popular and successful.

Overall Assessment

An excellent program that the other Military Services should consider adopting.

NAVAL AIR DEVELOPMENT CENTER COOPERATIVE EDUCATION PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Naval Air Development Center

Administering Office

Naval Air Development Center

Contact

Ms. Barbara Ward, Naval Air Development Center, (215) 441-2796

Objective

To provide an effective recruiting source to meet long-range engineering staffing goals, to support equal employment opportunities objectives, to permit selections for career jobs based on proven performance, to bring new educational methods and concepts into the workforce, and to strengthen relationships between educational institutions and at Naval Air Development Center (NADC).

Description

This program assists students to complete their baccalaureate degrees in science and engineering by alternating work at NADC and classroom instruction. Students may elect to become full-time employees at NADC upon graduation.

The Cooperative Education Program (COOP) at NADC was started 32-years ago. It provides a progressive work/study program for associate degrees in technical areas, and baccalaureate and graduate degrees in science and engineering.

All participants must have satisfactorily completed their first year of study. They can alternate between working and studying full-time, or they may work a minimum number of hours each week, while continuing to attend school.

NADC does not have a written agreement with participating colleges and universities.

Headquarters Navy has supported this program in the past, and has set aside centralized funds for minorities, who must meet the same criteria as other participants.

NADC currently has only 63 students enrolled in the program, down from nearly 200 in the past. Approximately 2-years ago the Navy instituted a "management to payroll" system, which establishes employment ceilings. With this system, however, supervisors are reluctant to set aside valuable billets for COOP students (NADC typically hires 75 scientists or engineers each year). As a result, the future of this program is now in doubt.

An advantage of the COOP program is the government commitment to permit participants to convert from the program to competitive service employment after college graduation. This can even be done during a hiring freeze, which provides even more assurance that NADC will meet its personnel needs.

Cost

The program cost $305,000 in FY89 for 63 students, or about $5,000 per student.

Legal Authority

Title 5 U.S.C. provides authority for training of government employees. Participants are hired into government service under Schedule B in accordance with 5 CFR 213.3202(a) and FPM 308. This regulation also permits conversion of the Schedule B appointment to competitive service (career or career-conditional) at any time within a 120-day period after satisfactory completion of a career-related, work-study program.

Evaluation

This program appears to be well managed and conducted by very committed personnel. However, the new accounting rules for managing the civilian payrolls are severely reducing this program in the last 2 years.

Nonetheless this program brings large numbers of quality scientists and engineers into the DoD civilian workforce at the baccalaureate level, and encourages minorities and women to become scientists and engineers as well as civilian employees.

Overall Assessment

The program is very good. It should be expanded so that it could satisfy the majority of NADC's new scientist and engineer manpower needs. To do so, however, the Office of Personnel Management would need to approve excluding COOP students from civilian ceilings.

Federal Junior Fellowship Program

Military Service/Defense Agency

Navy

Reporting Unit

Naval Research Laboratory

Administering Office

Naval Research Laboratory

Contact

Ms. Maragaret Copeland, Naval Research Laboratory, (202) 404-7955

Objective

To provide superior students with an opportunity to earn money for college and to learn about their chosen careers through related work experience study.

Description

Principally for college-level students, this provides employment during vacations and breaks to students specializing in science and engineering. Only academically gifted students with economic need are eligible for the program.

The program employs high school and college students during the summer months, on school breaks, and as schedules permit during the school year. All students are brought into Schedule B positions, which, like the COOP program, participants can be converted to competitive service when they complete their degrees. Only two students participated in this program during FY90.

Cost

The program cost $18,440 in FY89 for four students, or about $4,600 per student.

Legal Authority

Title 5 U.S.C. provides for hiring civilian employees of the Federal Government. The students in the program are hired under 5 CFR 213.3202f, which brings them into the excepted service as Schedule B employees.

Evaluation

This program focuses on scientific and engineering disciplines at the Naval Research Laboratory. Students are limited to 1,040 hours per year during vacations and breaks. This program works for a very small population. It provides good recruiting opportunities (rather than at campuses) and helps students obtain baccalaureate degrees in science and engineering. The eligibility restrictions are so narrow, however, that very few students apply or are hired.

Overall Assessment

This program has good objectives, but it could be replaced by other programs that reach more students.

Naval Research Laboratory Cooperative Education Program

Military Service/Defense Agency

Navy

Reporting Unit

Naval Research Laboratory

Administering Office

Naval Research Laboratory

Contact

Ms. Margaret Copeland, Naval Research Laboratory, (202) 404-7955

Objective

To provide NRL with a continuing source of entry-level engineers and scientists.

Description

This program provides part-time employment to students who are pursuing a baccalaureate degree in the fields of engineering, computer science, or the physical sciences. It is carried out in accordance with a planned schedule and a working agreement between the Naval Research Laboratory (NRL) and the educational institution.

The Cooperative Education Program (COOP) exposes students to career opportunities in the fields of science and engineering, the work environment, and the people who work in those fields. It also helps to pay school expenses.

Students alternate periods of full-time employment with full-time classroom work, although part-time work schedules also are allowed providing that such assignments satisfy the academic cooperative education curriculum. While following a part-time work schedule, students must continue to be enrolled in school on a full-time basis. Students may not work more than 2,600 hours during 2 consecutive years.

Upon completion of all requirements for a bachelor's degree and with the recommendation of the supervisor, the student's portion may be converted to a permanent appointment at either the GS-5 or GS-7 level.

The educational institutions refer prospective COOP students to NRL. All qualified students are then referred to NRC managers based on yearly surveys of personnel needs. The managers may interview students who live outside the Washington, D.C. area by telephone, and conduct personal interviews with local students. They also select the students that meet their personnel requirements.

This is a large program at NRL as approximately 90 students participated in FY90, down from 143 in FY87. Between 60 to 70 percent of the graduates convert successfully to full-time employment. The program could be expanded greatly, as NRL receives many more applications that it can accept.

Cost

The program cost $699,622 in FY89 for 119 students, or about $6,000 per student.

Legal Authority

Title 5 U.S.C. provides authority for training of government employees. Participants are hired into government service under Schedule B in accordance with 5 CFR 213.3202(a) and FPM 308. This regulation also permits conversion of the Schedule B appointment to competitive service (career or career-conditional) at any time within a 120-day period following satisfactory completion of a career-related, work-study program.

Evaluation

The program has significant merit and should be considered for expansion. We are concerned about the recent reduction in the numbers of participants because of stated budget reasons, attributed to the "manage to payroll" system used by Navy laboratories. This program could provide a larger share of NRL's baccalaureate degree needs and reduce its need to recruit at colleges and universities every year.

Overall Assessment

This program appears to be ably managed, but it's not achieving its full potential.

1,040 Hour Appointment Program

Military Service/Defense Agency

Navy

Reporting Unit

Naval Research Laboratory

Administering Office

Naval Research Laboratory

Contact

Ms. Pamela Cutchember, Naval Research Laboratory, (202) 767-3030

Objective

To supplement the Naval Research Laboratory's subprofessional staff, to encourage students to seek permanent employment upon graduation, and to expose students to a work environment in their field of study.

Description

This program provides employment to science and engineering students during vacations and breaks. All appointments are in the excepted service, which negates competitive-hiring procedures.

Students work up to 1,040 hours per year during year during vacations and breaks. They can be recruited after graduation, but cannot be automatically placed in a competitive position.

Cost

The program cost $372,688 in FY89 for about 80 students, or about $4,650 per student.

Legal Authority

Title 5 U.S.C. provides for hiring civilian employees of the Federal Governments, under 5 CFR 213.3102q, which brings them into the excepted service as Schedule A employees.

Evaluation

This is a good program. It provides good recruiting opportunities and helps students obtain baccalaureate degrees in science and engineering fields.

However, it lacks a formal mentor/student relationship that is so successful in other programs.

Overall Assessment

A very good program that could be expanded.

HISTORICALLY BLACK COLLEGES AND UNIVERSITIES/MINORITY INSTITUTIONS PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Research

Administering Office

Office of Naval Research

Contact

Dr. Bruce Robinson, Office of Naval Research

Objective

To increase the number and quality of minority college students in science and engineering, with a long-term goal of preparing minority students to pursue graduate study in critical science and engineering fields.

Description

This program provides

- grants to black and minority institutions as part of the Navy's set-aside program for small and disadvantage businesses to obtain research and development of interest to the Navy.

- grants to black colleges to improve their science and engineering educational programs by upgrading curriculum and faculty, bringing in visiting faculty, providing scholarships, and recruiting undergraduates from high schools.

Although the program has been in place since 1979, it was redirected in 1989 to focus directly on improved and expanded educational opportunities for undergraduates in science and engineering. Under that redirection, the Office of Naval Research made six grants in 1989, totaling $2.8 million to the following

institutions: Clark College, Florida A&M University, Grambling State University, Hampton University, Lincoln University, and Xavier University.

The Office of Naval Research plans to repeat grants for a total of 5 years. The objective of the grants is to assess the programs effectiveness in increasing the numbers of minority students who pursue graduate science and engineering degrees.

Cost

The total program cost in FY89 was $7.5 million (about $4.7M in research grants and $2.8M in educational grants.

Legal Authority

Title 10 U.S.C., Section 2358 provides authority for research and development grants, while the educational grants come under Executive Order 12677 which specifically directs support of historically black colleges and universities, and specifies support of "... alternative sources of faculty talent, particularly in the fields of science and technology ..."

Additionally, other statutes authorize initiatives to aid historically black colleges and universities and minority institutions, including Title 20 U.S.C., Chapter 28, Section 1060 and Title 42 U.S.C., Chapter 16, Section 1885.

Evaluation

The research portion of this program is not a science and engineering intervention program as defined in this study. The educational part of the program is designed to assist black colleges and universities to increase the number of their science and engineering students who go on to graduate school. However, the newness of the program precludes an evaluation at this time.

Overall Assessment

Impossible to assess at this time.

AIR FORCE COOPERATIVE EDUCATION PROGRAM

Military Service/Defense Agency

Air Force

Reporting Unit

Headquarters, U.S. Air Force

Administering Office

Directorate of Personnel

Contact

Ms. Sharman Thornton, Directorate of Personnel, (202) 693-7832/7834

Objective

To integrate academic studies and federal work experience for the purpose of broadening students' knowledge of their chosen career field in the Air Force.

Description

This program assists students to complete baccalaureate degrees in science and engineering while gaining valuable work experience at Air Force facilities. Employment is available at the end of the program.

For many years, the Air Force has had an extensive Cooperative Education Program (COOP), through which students can earn associate degrees in technical areas, and baccalaureate and graduate degrees in science and engineering. Currently, 1,242 students are enrolled as COOP students, down from 1,700 in 1988.

Under the program, students can alternate their work and study, or they can work a minimum number of hours each week while going to school at the same time. The Air Force uses a written agreement with all participating colleges and universities.

The Air force is about to establish a centrally managed and funded science and engineering COOP program that is targeted on minorities. This special

program would sponsor 20 students per year, but no funds has yet been provided.

Cost

The Air Force could not provide an estimate of the cost of this program.

Legal Authority

Title 5 U.S.C. provides authority for training of government employees, while 5 CFR 213.3203(a) and FPM 308 authorizes the hiring of COOP students under Schedule B. This regulation also permits conversion of the Schedule B appointment to competitive service (career or career-conditional) at any time within a 120-day period following satisfactory completion of a career-related, work-study program.

Evaluation

This program is not managed as aggressively as are similar Navy programs. The Air Force does not provide either centralized guidance or advertising. Some Air Force representatives are concerned about the recent down-turn in the number of participants. The two most likely explanations are the downsizing of the Air Force and the way payroll and personnel positions are managed (where temporary positions count toward personnel ceilings).

Overall Assessment

The program is good, but not as well managed as the Navy's. More centralized support is needed. It could be expanded back to previous levels so as to supply the majority of the Air Forces's new scientist and engineer manpower needs. The Air Force also should increase its efforts to encourage minorities and women to participate through the centralized targeted pool of funds as in the Navy.

In order to assure its future success, OPM approval is needed to exclude COOP students from civilian ceilings as with other programs, such as stay-in-school, summer employment, etc.

The program has a long history of successfully attracting qualified scientists and engineers to Federal employment. Its future, however, may not be so bright.

ANNEX B-3

Graduate Programs

Graduate Programs

GRADUATE STUDY AWARD PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Naval Air Development Center

Administering Office

Naval Air Development Center

Contact

Mr. Edward Calvello, Naval Air Development Center, (215) 441-1020

Objective

To give selected Naval Air Development Center (NADC) employees an opportunity to acquire critical, urgently required, graduate-level education in science or engineering.

Description

This program provides NADC employees an opportunity to attend leading graduate schools for the purpose of obtaining state-of-the art technical education, leading to a master's or doctorate in science or engineering.

All NADC employees with a minimum of 1 year of service are eligible to apply. They need a recommendation from their supervisor, acceptance from a school of their choice in a field of study meeting NADC's needs, and approval by a screening committee.

For those employees enrolled at the master's level, the program provides 9 months of schooling, with full tuition, salary, and relocation expenses. Above

the master's level, the program provides 18 months of schooling with the same expenses paid. All participants must sign an agreement stating that they will pay back each year of education with 3 years of service.

If required, the participants must obtain waivers to exceed the Office of Personnel Management's 1-year limit on the length of training received at Government expense during the first 10 years of service and its 2-year training limit during the current 10 years of service. Those waivers are usually obtained with little difficulty.

The program encourages minority and female-staff members to participate. In FY89, the program included four women and five males.

Cost

The program cost $800,000 in FY89 for 21 students, or about $38,000 per student.

Legal Authority

Title 5 gives the authority for Government support of education and training of government employees. Federal Personnel Manual, Chapter 410, provides the implementing regulations.

Evaluation

This program appears to be well managed. It also:

- Provides large numbers of quality science and engineering employees with advanced technical education in support of NADC's mission.
- Encourages minorities and women to obtain advanced degrees as part of NADC'S technical workforce.
- Retains participants after completing school for a committed period of time — 3 - 6 years — as part of NADC's workforce.

Overall Assessment

This is an excellent program, which could be expanded. It could meet most of NADC's requirements for scientists and engineers with advanced degrees. It also provides opportunities for minorities and women.

GRADUATE FELLOWSHIP PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Research

Administering Office

American Society for Engineering Education (contractor)

Contact

Ms. Debora Hughes, Office of Naval Research, (703) 696-4108

Objective

To increase the pool of U.S. scientists and engineers trained at the doctoral level and able to work on science and engineering issues of critical national concern.

Description

This program assists recent graduates with bachelor's degrees to pursue doctorates in designated science and engineering areas at accredited U.S. colleges and universities.

Started in 1982, this program provides a 3-year grant to selectees (2 years for course work and 1 year for research) leading to a doctorate. Each must suggest an original research topic, and may attend a school of choice.

Applications are submitted to the American Society of Engineering Education (ASEE), which establishes 11 panels of experts (by discipline) to review them. The Office of Naval Research approves the composition of the panels and has one of its research officers on each panel. The panels rank the students on the basis of ability, credentials, and potential, with minority applicants provided a special evaluation. The Office of Naval Research reviews and approves the ranking and ASEE provides the grants.

In 1990, 863 students applied for grants, but 150 were ineligible because they had already started on master's programs. Of the remainder, 50 were selected, with about a 10 percent turndown rate. Minorities were well represented in the group of 50: five of six Hispanics accepted; one American Indian and one Pacific Islander were offered grants, and they both accepted; but three of the four blacks offered grants declined.

The 3-year grants are good over a 5-year period. If necessary, students can work for a year to increase their income or take care of personnel needs and still complete their education within the 5-year period. The program's attrition rate is only 7 percent over the period of the grant. Most students state that they would not have finished the program without the assistance.

Cost

The program cost $4,000,000 in FY89 for 150 enrollees, or about $27,000 per student per year.

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program appears to meet the Navy's objectives of increasing the numbers of scientists and engineers, trained at the Ph.D. level. However, we do not see any emphasis on tailoring research towards the Navy's requirements or recruiting the graduates to perform research for the Navy. We believe that the ASEE review panels could add interest in Navy research issues to their deliberations with little trouble. That action would have the secondary benefit of making the students knowledgeable of Navy research and development objectives, which could result in them receiving research grants following receipt of their doctorate.

Overall Assessment

This is a good program. Nonetheless, we believe that it could be more closely focused on Navy research and development needs.

PALACE KNIGHT/PALACE ACQUIRE INTERN PROGRAMS

Military Service/Defense Agency

Air Force

Reporting Unit

Headquarters, U.S. Air Force

Administering Office

Air Force Civilian Personnel Management Center, San Antonio, Texas

Contact

Mr. Edward Lee, Air Force Civilian Personnel Management Center, (512) 652-2252

Objective

To attract and retain high-quality science and engineering employees.

Description

Although quite similar, these programs have slightly different structures and focuses:

- PALACE ACQUIRE offers high-quality college graduates in science and engineering intern positions in Air Force laboratories along with a commitment to send them to graduate school to obtain a master's degree during the 3-year intern period.

- PALACE KNIGHT offers exceptionally high-quality college graduates in science and engineering GS-7 positions in Air Force laboratories along with a commitment to send them to graduate school immediately to obtain a master's degree and a follow-on commitment to provide additional graduate education toward a Ph.D. degree.

The PALACE ACQUIRE program started in 1986, with the PALACE KNIGHT program beginning in FY90. The PALACE ACQUIRE candidates must have a college grade point average of 3.1, and PALACE KNIGHT candidates

must have a 3.25. Candidates must be accepted into a graduate program of interest to the Air Force before they are considered for hire. They also must agree to work for the Government for a period equal to three times the length of the graduate training.

The PALACE ACQUIRE program brings participants into an intern program where they receive on-the-job training for the first year. During the second year, they attend college to receive a master's degree. Then they return to the laboratories for one additional year of on-the-job training before receiving permanent assignments in the laboratory.

Under PALACE KNIGHT, participants report directly to a college for a period of 12 months to obtain a master's degree. Then they are assigned to specific jobs in a laboratory. Within three years, they are sent back to college to obtain a Ph.D. degree.

In the first year of the PALACE KNIGHT program, FY90, the Air Force's goal was to hire 40 individuals. Those selected had a grade point average of 3.7 and average Scholastic Aptitude Test scores of 1,300. The Air Force's long term objective is to hire 100 employees through this program each year for the next 5 years. The Air Force centrally funds this program, as well as accounts for the personnel positions (which means that the laboratories do not have to use their spaces for the students). The laboratories must, however, assure that a space will be there when the students complete their course work.

Cost

PALACE ACQUIRE cost $709,453 in 1989 for 49 employees, or about $15,000 each, excluding salaries. The cost of PALACE KNIGHT was not available.

Legal Authority

Title 5 provides authority for training of government employees. Participants are hired into government service as career employees under direct hiring authority and sent to training in accordance to procedures authorized in the Federal Personnel Manual, Chapter 410.

Evaluation

These programs are centrally managed and funded. Their objectives are excellent and PALACE ACQUIRE appears to be succeeding. It is still too early to assess the contribution of PALACE KNIGHT. One of the keys to that success is whether the civil service rules will permit the Air Force to award two years of college at the Ph.D. level. The Air Force is working with the Office of the Secretary of Defense and the Office of Personnel Management to obtain this flexibility.

Overall Assessment

These programs are very good and could serve as models for the other Military Services. They bring science and engineering employees into the workforce and increase the quality of the science and engineering personnel employed by the Government. The central funding and accounting for personnel spaces are keys to their early successes.

Air Force Research in Aero Propulsion Technology Program

Military Service/Defense Agency

Air Force

Reporting Unit

Office of Scientific Research

Administering Office

Office of Scientific Research

Contact

Lt.Col. Claude Cavender, Office of Scientific Research, (202) 767-4970.

Objective

To increase the number of U.S. scientists and engineers educated at the doctoral level on aero propulsion technology.

Description

This program provides for a graduate-level cooperative study program involving five universities and five gas turbine engine companies. The participant completes graduate coursework and research at one of the universities, and also serves as an industrial trainee at one of the companies. Approximately two-thirds of the participants pursue a master's degree. All participants receive a stipend of $1,400 per month, plus full tuition.

Applications are reviewed and evaluated by both the companies and universities. In 1989, 23 offers were made and 14 were accepted. Final approval and offers are made by AF/OSR. At the end of their work/study program, each participant sends the Air Force a report which often corresponds to their thesis or dissertation.

Cost

This program cost $908,000 in FY89 for 45 enrollees, or about $21,000 per student per year.

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities. Participants are not federal civilian employees. They receive grants covering a stipend, tuition, and expenses.

Evaluation

This program focuses on a specific Air Force research requirement. In doing so, the Air Force obtains pertinent research results, assures a steady supply of highly-trained science and engineering personnel in a particular field, and maintains good communication with academia and gas turbine companies.

This program also seems to be very well organized and operated.

Overall Assessment

This is a good program. As a result of this program, it clearly helps to improve the number of scientists and engineers trained in propulsion technology which can directly benefit the Air Force.

GRADUATE STUDENT RESEARCH PROGRAM

Military Service/Defense Agency

Air Force

Reporting Unit

Office of Scientific Research

Administering Office

Research and Development Laboratories, Inc. (Contractor)

Contact

Lt.Col. Claude Cavender, Office of Scientific Research, (202) 767-4970

Objective

To provide graduate students a means to participate in research at an Air Force laboratory; stimulate continuing professional association among graduate students, faculty advisors, and Air Force technical personnel; further the research objectives of the Air Force; and expose graduate students to potential thesis topics.

Description

This research program introduces the academic community to the research and technology requirements of the Air Force; it also establishes a continuing relationship between academia and the Air Force.

This program is related to an Air Force postdoctoral program: Summer Faculty Research Program (SFRP). Graduate students work with faculty researchers, who are supported through the SFRP, at Air Force laboratories during the summer break. The SFRP faculty are encouraged to bring graduate students along to assist them in their research; those students are then generally accepted by the Air Force in its Graduate Students Research Program. When a faculty member cannot or does not bring a graduate student, then the Air Force selects other graduate students as to aid the faculty member. The graduate students assist the faculty members accomplish their research during a 10-week summer period. The contractor hires all faculty members and graduate students as consultants

There are approximately 100 graduate students assigned to Air Force laboratories each summer. The graduate students were added to this program in 1982.

Cost

The program cost $810,000 in FY89 for 100 students, or about $8,100 per student.

Legal Authority

Title 10 U.S.C., Section 2358 permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program appears to satisfy the Air Force's objectives of developing awareness in the academic community of its research and development interests and requirements. It also assists the graduate students to pursue their advanced degrees.

The program also seems to be very well organized and operated. The Air Force clearly is pleased with the program, as are the participants based upon the numbers of applicants.

Overall Assessment

This is a good program. Nonetheless, the Air Force has no evidence that any of these personnel ever become Federal employees or in particular, work for the Air Force.

ANNEX B-4

Postdoctoral/Faculty Programs

Postdoctoral/Faculty Programs

National Research Council Postdoctorate Research Associateship Program

Military Service/Defense Agency

Department of Defense

Reporting Unit

Participating Military Services and Defense Agencies

Administering Office

National Research Council of the National Academy of Sciences (contractor)

Contact

Dr. Arnold E. Schwartz, National Research Council, (202) 334-2787.

Objective

To provide postdoctoral scientists and engineers of unusual promise and ability opportunities for research on problems, largely of their own choice, that are of interest to the sponsoring DoD laboratories.

Description

This program provides 2-year grants to postdoctoral researchers who received their degree within the past 5 years. The participants are assigned to DoD laboratories for purposes of conducting hands-on research and development in Defense critical mission areas. The grants range from $27,150 to $35,000, depending on the laboratory. The National Research Council actually makes the grants from funds made available by the laboratories.

Each applicant submits a research proposal to a laboratory or directly to the National Research Council. The Council establishes technical panels to review and grade the proposals. The applicant list in order of rank is then sent to the

laboratories for their final selection. Applicants must be selected in the order determined by the National Council.

The National Research Council receives approximately 1,100 applications each year, and approves 800 to 900. About 400 awards are made annually.

The laboratories that participate in this program include the: Naval Research Laboratory, Navy Oceanographic and Atmospheric Research Laboratory, Navy Ocean Systems Center, Navy Postgraduate School, Army Research Office, Air Force Office of Scientific Research and the Defense Nuclear Agency. Others may have participants, but did not report this program to OSD.

The Naval Research Laboratory, for example, received 66 applications in 1988. The National Research Council approved 54, and the laboratory accepted 22. Laboratory representatives estimate that they hire about 25 percent of the researchers each year.

Cost

Total program costs are not known; stipends range from $27,150 to $35,000 for each participant.

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program has one primary objective: to identify postdoctoral researchers who can do high-quality research in areas of vital interest to the DoD. It apparently is satisfying that objective.

Overall Assessment

This is a good program and warrants expansion to other laboratories throughout the DoD.

LABORATORY RESEARCH COOPERATIVE PROGRAM

Military Service/Defense Agency

Army

Reporting Unit

Army Research Office

Administering Office

Battelle (contractor)

Contact

Mr. Hodges Throckmorton, Army Research Office, (919) 549-0641

Objective

To solve scientific and technical problems common among Government laboratories, advance the state of the art within the discipline under study, and foster an awareness of Government programs available to universities.

Description

This program assists Army laboratories to solve technical problems by augmenting laboratory staff with college and university faculty for 3-month periods.

A Government laboratory identifies research work that it needs to perform and a researcher who is capable of carrying out the research. If a researcher is not known to the laboratory, it may ask the Army Research Office to suggest potential researchers. The laboratory then sends a statement of work to the Army Research Office along with the funds to accomplish the work. That statement of work is then forwarded to Battelle, which completes the contractual arrangements. All researchers are subcontractors to the Army Research Office. Researchers are not required to be U.S. citizens; they also accomplish mostly unclassified work. At the end of the project, the researcher submits a report to the laboratory.

Cost

The LRCP cost $141,000 in FY90 for 10 faculty members, or about $14,000 per faculty.

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program is not an intervention program for the purpose of increasing the numbers of scientists and engineers or of improving the quality of scientists and engineers.

Overall Assessment

This program should not be included in this project.

Summer Faculty Research and Engineering Program

Military Service/Defense Agency

Army

Reporting Unit

Army Research Office

Administering Office

Battelle (contractor)

Contact

Mr. Hodges Throckmorton, Army Research Office, (919) 549-0641

Objective

To further research interests of the U.S. Army, stimulate communication between faculty members and Army professionals, and enhance research capabilities of scientists from educational institutions.

Description

This program promotes collaborative research and exchange of information among university, college, and Army scientists and engineers by hiring faculty members to work at Army laboratories during the summer.

Announcements listing the general disciplines and subdisciplines of interest to Army laboratories are sent widely to colleges, universities, technical institutions, community colleges, and past participants. All interested researchers send their applications directly to Battelle. In turn, Battelle forwards the applications to the appropriate laboratories, which review the applications and select the researchers that best meet their requirements. The scope of research interests by the laboraties is quite broad. Some laboratories define actual research projects, while other laboratories design tasks around researchers selected. Each laboratory funds researchers that it hires.

This program started in 1983. Approximately 50 percent of the researchers participated previously. Each researcher is paid $800 per week plus a per diem under a subcontract to Battelle. At the end of the research, each a researcher submits a report to the Army laboratory and to Battelle. The numbers of participants since 1987 have averaged slightly more than 100 each summer.

Cost

This program cost $1,220,000 in FY90 for 113 faculty, or about $11,000 per faculty (the Army, however, indicated that the researchers averaged $10,000 in salary and another $5,000 in per diem).

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program is similar to programs operated by the Navy and Air Force which bring in college and university faculty to accomplish research in service laboratories. The Army program also does not appear to operate as effectively as

the Air Force program. Unlike the Air Force program, however, the Army does not include graduate students together with the principal researcher. Therefore, a valuable opportunity to help graduate students as well as to cultivate future Army employees is lost.

Overall Assessment

This program misses an opportunity to focus research and to recruit outstanding graduate students.

WOMEN SCIENCES SCHOLARS PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Research

Administering Office

Bunting Institute of Radcliffe College, Cambridge, Massachusetts (contractor)

Contact

Ms. Debora Hughes, Office of Naval Research, (703) 696-4108.

Objective

To encourage continued research and study in defense-critical areas, by women that recently received doctorate degrees.

Description

This program gives women researchers an opportunity to further their research in their field for a period of one year.

Each applicant submits a research proposal along with a collaboration statement that explains the relationship of the research to be performed and the university laboratory where it will be accomplished. At the end of the research period, the Navy is provided a report on the results of the research. The program has been in existence since 1980.

All applicants must have received a Ph.D. within the past two years, be a U.S. citizen, and relate the proposed project to further development of women in that area of research.

The Bunting Institute supports the research of about 45 women in various disciplines. The Navy grant supports 8 of those 45. Within the past two years, the Navy has attempted to tailor the research that it funds to more closely match its requirements. The results of this effort are not yet clear.

Cost

The WSS cost $174,000 in FY89, for eight selectees, or about $22,500 per student per year.

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program has an important objective to assist new women scientists and engineers to accomplish postdoctoral research in their fields and thereby provide them better capabilities to compete in their fields. During the early years of the program, the Bunting Institute did not necessarily select students to do research that the Navy could use. The Navy basically got no product for their money.

Since 1988, however, Bunting has changed and its new administration is closer with the Navy to correct the sort comings.

Overall Assessment

This is a good program and achieve its objectives. Nonetheless, we agree with the navy that the research it sponsors needs to be more closely tied to its requirements.

YOUNG INVESTIGATOR PROGRAM

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Research

Administering Office

Office of Naval Research

Contact

Dr. Donald Polk, Office of Naval Research, (703) 696-4103

Objective

To encourage continued research and study, by recent scientists and engineers who recently were awarded doctorate degrees.

Description

This program provides 3-year grants scientists and engineers to perform research in areas of interest to the Navy. The participants, all whom received a Ph.D. within the proceeding 5 years, are provided $50,000 to $75,000 a year. The grant does not include the cost of equipment, but it does cover the cost of graduate assistants. The grant goes directly to the college or university. All participants must be in a tenure track at a university and perform campus-based research.

To apply for a grant, the researcher submits a proposal to the Office of Naval Research, which then makes the final selection. The Office of Naval Research awarded 13 new grants in FY90.

The hope is for a long-term relationship for these researchers to do continuing research for the Navy. The Navy gets the product of the research. Selections are not targeted in anyway. Women and Hispanics are in the program, however, in small numbers. Applicants have never turned down selections.

Cost

This program cost $2,500,000 in FY89 for about 44 participants, or $57,000 for each participant.

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program has an important objective: to identify highly-trained researchers to perform research in areas of vital interest to the Navy. It appears to be very well organized and effective.

Overall Assessment

This is a good program and achieving its objectives. However, there is no evidence that any of these personnel ever become employees of the government in Navy research and development activities or that there is any Navy interest in using this program as a recruiting vehicle.

Office of Naval Technology Postdoctoral Fellowship Program

Military Service/Defense Agency

Navy

Reporting Unit

Office of Naval Technology

Administering Office

American Society for Engineering Education (contractor)

Contact

Mr. Paul Quinn, Office of Naval Technology, (203) 696-4453

Objective

To encourage continued research and study by scientists and engineers that recently were awarded doctorate degrees.

Description

This program provides 1-year grants to scientists and engineers to conduct research in areas of interest to the Navy. The recipients work in Navy laboratories, concentrating on hands-on research and development in support. In awarding grants, the Office of Naval Technology stresses application of technology, rather than basic research.

Each applicant submits a research proposal to the American Society of engineering Education, following extensive discussions with a research member at a Navy laboratory. Proposals can be submitted at four different dates during the year. The Society renews all proposals and provides its recommendations to the Office of Naval Technology. Each year, approximately 15 new fellowships are awarded and funded.

All applicants must have received a Ph.D. within the last seven years, be a U.S. citizen, and be able to relate the research project to critical Navy research needs. The majority of those awarded grants, however, obtained their Ph.D.s within the proceeding 4 years.

Some researchers, depending on the area of research and the laboratory's interests, are invited to extend their research for up to a total of 3 years. Costs for additional research offer the first year is paid for by the laboratory. At the conclusion of the grant, each researcher submits a report to the Navy.

The program has been in existence since 1982. Within the past 2 years, however, the Navy has refocused its selection process and increased the size of its grants to attract more engineers and computer scientists. The grants vary between $36,000 to $40,000 for scientists, $37,000 to $45,000 for engineers and computer scientists, and up to $53,000 for medical specialists. As a result of the increased stipends, the Navy is also trying to change the focus of the research more toward applied research (which is the responsibility of ONT), instead of basic research (which is the responsibility of the Office of Naval Research).

From inception of the program through September 1989, the Navy has received 237 applications, made 174 offers, and received 126 acceptances. In addition, the Navy estimates that over 50 percent of the researchers subsequently become full-time employees.

Cost

This program cost $2,200,000 in FY89 for about 75 participants. The total cost for each participant while actually accomplishing research is estimated to be about $45,000.

Legal Authority

Title 10 U.S.C., Section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program satisfies it primary objective: new Ph.D. — level scientists and engineers to conduct research in areas of vital interest to the Navy. It has the secondary purpose of being a recruiting vehicle for new Navy researchers (having a record of over 50percent recruiting).

The recent changes of increasing the stipends for engineers and computer scientists and focusing more on applied research instead of basic research are very good changes.

Overall Assessment

This program appears to be well organized and effective. In addition, it seems to be a very successful recruiting program.

University Resident Research Program

Military Service/Defense Agency

Air Force

Reporting Unit

Office of Scientific Research

Administering Office

Office of Scientific Research

Contact

Lt.Col. Claude Cavender, Office of Scientific Research, (202) 767-4970.

Objective

To bring faculty members from colleges and universities to perform research at Air Force laboratories.

Description

The program provides for highly qualified colleges and university faculty members to spend 1 or 2 years at Air Force laboratories working on research problems of interest to the Air Force.

All participants continue to be paid by their colleges or universities, but the Air Force reimburses the colleges or universities for those costs plus it covers the cost of travel and moving. Participants have the status of visiting scientists or engineers in the laboratory and are subject to the general conditions of the laboratory.

Appointments may start at any time during the year. Participants must be U.S. citizens and a full-time faculty member in a science or engineering department.

Prospective participants send their applications, including a proposed area of research, directly to the chief scientist in the laboratory where they want to work. The laboratory sends a letter of endorsement, along with the application, to the Office of Scientific of Research for review by the scientific director for the associated discipline. The director then submits a recommendation to the Commander, Office of Scientific Research and the technical director.

Although the program provides for up to 2 years of research, less than half of the researchers actually stay the second year. Sometimes, a laboratory will extend the services of a researcher out of its own funds.

All researchers must submit a final research report when they conclude this research.

Cost

This program cost $1,942,000 in FY89 for 24 participants, or about $81,000 per researcher.

Legal Authority

The Intergovernmental Personnel Act of 1970, as amended (P.L. 91-648), allows exchange of personnel between the private sector and the government. Title 10 U.S.C, Section 2358 permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

This program provides many benefits: it adds to the research capability of the Air Force; it enhances the researcher's technical skills and reputation; and facilitates the interchange of information between the Air Force and academia. The program does little to increase the overall population in the scientist and engineering pool, however.

Overall Assessment

This program plays an important role in improving the quality of the scientist and engineering pool.

Summer Faculty Research Program and Research Initiation

Military Service/Defense Agency

Air Force

Reporting Unit

Office of Scientific Research

Administering Office

Research and Development Laboratories, Inc., Culver City, California (contractor)

Contact

Lt.Col. Claude Cavender, Office of Scientific Research, (202) 767-4970.

Objective

The objectives of the Summer Faculty Research Program (SFRP) include: to develop a basis for continuing research of interest to the Air Force, to stimulate continuing relations among faculty members and their professional peers in the Air Force, and to enhance the research interests and capabilities of scientific engineering educators in scientific areas of interest to the Air Force.

The objective of Research Initiation Program (RIP) is to enable faculty members to continue the research initiated under the SFRP at their academic institutions.

Description

These programs introduce to the academic community the Air Force's research requirements; they also establish a continuing technical relationship with that community. Both faculty and graduate students are brought into this program.

These programs are also related to the Graduate Student Research Program, described in the graduate section of this appendix.

The SFRP is the center piece of these three programs. Faculty members submit research proposals in response to announcements and advertisements that outline their research and how it would benefit the Air Force. If their proposals are selected, the faculty members perform research during a 10-week summer period at Air Force laboratories.

The program give special consideration to faculty at historically black colleges and universities and to faculty members not previously selected. Both the faculty members and the graduate students are hired as consultants to the contractor.

Faculty members are encouraged to bring a graduate student to assist in the research. If a faculty member does not designated a particular graduate student, the Air Force selects one or more graduate students to assist on the research. At the end of the period, faculty members are encouraged to apply for additional grants to continue their research, on-campus during the next academic year. Approximately half of the summer faculty receive those additional grants.

The Air Force has approximately 150 faculty member participants in the SFRP. The SFRP began in 1975, with the RIP beginning several years later.

Cost

The SFRP cost $1,600,000 in FY89 for 150 faculty members, or about $11,000 per faculty members. The RIP cost $1,700,000 in FY89 for 75 faculty members, or about $23,000 each.

Legal Authority

The Intergovernmental Personnel Act of 1970, as amended (P.L. 91-648), allows the exchange of personnel between the private sector and the government. Title 10 U.S.C, section 2358, permits the expenditure of funds for grants and studies in furtherance of military research activities.

Evaluation

These programs appears to satisfy the Air Force's interest in developing its research needs in the academic community. In addition, the graduate students benefit from the opportunity to assist in the research at Air Force laboratories.

Overall Assessment

These programs are well organized and operated. Valuable research is obtained and graduate students are aided toward obtaining their doctorate degrees.

However, we have not seen any evidence that many faculty members or graduate students seek employment with the Air Force.

APPENDIX C

Tables Supporting Figures Contained in the Main Text

Tables Supporting Figures Contained in the Main Text

Table C-1.
United States Demographics (by race, ethnicity, and selected age) (in millions)

	Historic					Projected			
	1970	1975	1980	1985	1990[a]	1995	2000	2005	2010
Race/ethnicity									
White	179.6	187.6	195.6	203.2	209.2	218.3	226.3	233.3	240.3
Black (non-Hispanic)	22.8	24.8	26.9	29.0	30.6	33.1	35.5	37.8	40.2
Asian/Pacific Islander	N/A	N/A	3.8	5.5	7.6	9.8	12.1	14.6	17.2
American Indian/ Alaskan Native	N/A	N/A	1.4	1.6	2.1	2.2	2.4	2.5	2.7
Hispanic[b]	9.3	11.2	14.6	17.9	22.6	27.0	31.2	35.7	40.5
Age									
18 to 24	24.7	28.0	30.3	28.7	26.9	25.5	25.9	28.2	30.2
White	21.5	24.0	25.6	23.8	21.8	20.3	20.5	22.1	23.4
Black	2.8	3.5	4.0	4.0	3.8	3.8	3.9	4.2	4.7
Hispanic[b]	N/A	1.5	2.3	2.6	3.2	3.2	3.5	4.1	4.9
18	3.8	4.3	4.3	3.6	3.4	3.4	3.9	4.1	4.5
22	3.5	3.9	4.3	4.2	3.6	3.6	3.5	4.0	4.1
Total U.S. population	205.1	216.0	227.7	239.3	249.4	263.4	276.6	288.3	300.4

Sources: *Historic (1970 – 1985):* Miller, Louisa and Jennifer Marks. *Preliminary Estimates of the Population of the United States, by Age, Sex, and Race: 1970 to 1981.* Washington, D.C.: US. Bureau of the Census, current Population Reports, Population Estimates and Projections (Series P-25, No. 917), July 1982, pp. 9, 10, 17, 18, 24, and 25; Hollman, Frederick W. *United States Population Estimates, by Age, Sex, Race, and Hispanic Origin: 1980 to 1988.* Washington, D.C.: U.S. Bureau of the Census, Current Population Reports, Population Estimates and Projections (Series P-25, No. 1045), January 1990, pp. 7 and 11; and Hollmann, Frederick W. *United States Population Estimates, by Age, Sex, Race, and Hispanic Origin: 1989.* Washington, D.C.: U.S. Bureau of the Census, Current Population Reports, Population Estimates and Projections (Series P-25, No. 1057), March 1990, pp. 3 and 7.

Estimated and Projected (1990 – 2010): Day, Jennifer Cheeseman. *Population Projections of the United States, by Age, Sex, Race, and Hispanic Origin: 1993 to 2050,* Washington, D.C.: U.S. Bureau of the Census. Current population Reports, (Series P-25, No. 1104), November 1993, pp. xxiii, xxv, xxvi, 16, 26, 36, and 38. Middle Series.

Notes: N/A = not avaialble. This table supports Figure 2-1 and 2-2 in the text.

[a] Estimate.

[b] Persons of Hispanic origin may be of any race.

Table C-2.
Enrollments in U.S. Institutions of Higher Education (by selected categories) (in millions)

	Historic					Projected		
	1970	1975	1980	1985	1990	1995[a]	2000[a]	2004[a]
By type of school								
Private	2.2	2.4	2.6	2.7	3.0	3.2	3.4	3.5
Public	6.4	8.8	9.5	9.5	10.8	11.7	12.1	12.4
By gender								
Male	5.0	6.2	5.9	5.8	6.3	6.8	7.0	7.2
Female	3.6	5.0	6.2	6.4	7.5	8.2	8.5	8.7
By age								
18-to-24	6.2	7.1	7.6	7.2	7.6	7.6	7.9	8.5
25-to-34	1.6	2.7	3.1	3.2	3.4	3.5	3.3	3.2
35 and over	0.8	1.4	1.4	1.9	2.6	2.6	3.4	3.3
By race/ethnicity								
White	N/A	N/A	9.8	9.9	10.7	N/A	N/A	N/A
Black (Non-Hispanic)	N/A	N/A	1.1	1.1	1.2	N/A	N/A	N/A
Hispanic[b]	N/A	N/A	0.5	0.6	0.8	N/A	N/A	N/A
Asian/Pacific Islander	N/A	N/A	0.3	0.4	0.6	N/A	N/A	N/A
American Indian/ Alaskan Native	N/A	N/A	0.1	0.1	0.1	N/A	N/A	N/A
By academic level								
Undergraduate	7.4	9.7	10.5	10.5	12.0	12.8	13.3	13.7
Graduate	1.0	1.3	1.3	1.4	1.6	1.9	1.8	1.8
First professional	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Total U.S. college enrollments	8.6	11.2	12.1	12.2	13.8	14.9	15.5	15.9

Sources: *Historic (1970 – 1990):* Snyder, Thomas D., Project Director. *Digest of Education Statistics, 1993.* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics, (NCES 93-292), October 1993, pp. 174, 175, 179, 187, 188, and 205.

Projected (1990 – 2004): Gerald, Debra E., et al. *Projections of Education Statistics to 2004.* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics (NCES 93-256), September 1993, pp. 26, 29, 31, 37 – 40, and 43.

Notes: N/A = not available. This table supports Figures 2-3 through 2-6 in the text.

[a] Middle alternative projections.

[b] Persons of Hispanic origin may be of any race.

Table C-3.
U.S. College Degrees Conferred (by level)
(in thousands)

	Historic					Projected		
	1970	1975	1980	1985	1990	1995	2000	2004
Associate	206	360	401	455	455	518	528	560
Bachelor	793	923	929	979	1,051	1,178	1,190	1,278
Master	208	292	298	286	324	377	371	363
Doctor	30	34	33	33	38	41	41	41
First professional	35	56	70	75	71	75	74	74
Total U.S. college degrees conferred	1,272	1,666	1,731	1,817	1,939	2,189	2,204	2,316

Sources: *Historic (1970 – 1990):* Snyder (NCES 93-292). p. 243.
Projected (1995 – 2004): Gerald (NCES 93-256). pp. 60 – 64.
Note: This table supports Figure 2-7 in the text.

Table C-4.
Bachelor's Degrees Conferred (by selected fields)
(in thousands)

	1970	1975	1980	1985	1990	1991[a]
Life sciencies	37	52	46	38	37	40
Physical sciences	21	21	23	24	16	16
Mathematics	27	18	11	15	15	15
Computer science	2	5	11	39	27	25
Engineering	50	47	69	96	82	79
Total degrees in S & E	137	143	160	212	177	175

Source: Snyder (NCES 93-292). pp. 248 – 255 and 256 – 263.
Note: This table supports Figure 2-8 in the text.
[a] Preliminary data.

Table C-5.
U.S. Bachelor's Degrees Conferred Upon Selected Groups (by race and ethnicity and selected fields) (in thousands)

	1977[a]	1980	1985	1990	1991[b]
White					
Life sciences	47.6	40.0	31.8	29.6	31.0
Physical sciences	20.2	20.9	20.7	13.4	13.5
Mathematics	12.5	9.8	12.2	12.0	11.9
Computer science	5.5	10.0	31.3	19.7	17.9
Engineering	41.4	56.3	76.4	63.0	60.1
Black (non-Hispanic)					
Life sciences	2.4	2.4	2.0	2.0	2.2
Physical sciences	0.7	0.8	0.8	0.7	0.8
Mathematics	0.7	0.6	0.8	0.7	0.8
Computer science	0.4	0.6	2.1	2.3	2.1
Engineering	1.4	2.1	3.2	3.3	3.5
Hispanic[c]					
Life sciences	1.0	1.1	1.2	1.3	1.5
Physical sciences	0.3	0.4	0.4	0.4	0.4
Mathematics	0.2	0.2	0.3	0.4	0.4
Computer science	0.1	0.2	0.8	0.9	0.9
Engineering	0.9	1.3	2.2	2.6	2.6
American Indian/ Alaskan Native					
Life sciences	0.2	0.1	0.2	0.1	0.2
Physical sciences	0.1	0.1	0.1	–	0.1
Mathematics	[d]	–	0.1	[d]	[d]
Computer science	[d]	–	0.1	–	0.1
Engineering	0.1	0.2	0.3	0.2	0.2
Asian/Pacific Islander					
Life sciences	1.3	1.5	2.0	3.3	3.6
Physical sciences	0.4	0.5	0.8	1.0	1.0
Mathematics	0.3	0.4	0.9	0.9	0.9
Computer science	0.2	0.5	2.0	2.3	2.1
Engineering	1.2	2.5	5.0	6.9	7.1

Sources: *(1977 – 1985):* Baker, Curtis O., ed. *Education Indicators: 1989.* Washington, DC: U.S. Department of Education, National Center for Education Statistics, pp. 241 – 243; *and (1990 – 1991):* Snyder (NCES 93-292), pp. 276 and 277.

Note: This table supports Figures 2-9 through 2-14 in the text.

[a] Race/ethnicity data by field first available in 1977.

[b] Preliminary data.

[c] Persons of Hispanic origin may be of any race.

[d] Less than 100.

Table C-6.

U.S. Bachelor's Degrees Conferred (by gender) (in thousands)

	1970	1975	1980	1985	1990	1991[a]
Male	451	505	474	483	491	496
Female	341	418	456	497	558	585
Total bachelor's degrees conferred	792	923	930	980	1,049	1,081

Source: Snyder (NCES 93-292). pp. 243, 276, and 277.

Note: This table supports Figure 2-15 in the text.

[a] Preliminary data.

Table C-7.

U.S. Bachelor's Degrees Conferred Upon Women (by selected fields) (in thousands)

	1971[a]	1975	1980	1985	1990	1991[b]
Life sciences	10.4	17.1	19.4	18.4	19.0	20.1
Physical sciences	3.0	3.8	5.6	6.6	5.0	5.2
Mathematics	9.4	7.6	4.8	7.0	6.7	6.9
Computer science	0.3	1.0	3.7	14.3	8.1	7.4
Engineering	0.4	1.0	6.4	12.7	11.3	11.0
Total bachelor's degrees conferred on women in S&E	23.5	30.5	39.9	59.0	50.1	50.6

Sources: (1971 – 1985): Baker (NCES 89-653). p. 254; and (1990 – 1991): Snyder (NCES (93-292). pp. 276 and 277.

Note: This table supports Figure 2-16 in the text.

[a] Data for 1970 not available.

[b] Preliminary data.

Table C-8.
U.S. Bachelor's Degrees Conferred Upon Foreign Students (by selected fields) (in thousands)

	1977[a]	1980	1985	1990	1991[b]
Life sciences	1.0	0.9	0.9	0.9	1.1
Physical sciences	0.6	0.7	0.8	0.6	0.6
Mathematics	0.3	0.4	0.8	0.5	0.6
Computer science	0.3	0.6	2.1	2.0	2.0
Engineering	3.6	5.8	7.4	5.6	5.3
Total bachelor's degrees conferred on foreign students in S & E	5.8	8.4	12.0	9.6	9.6

Sources: (1977 – 1985): Baker (NCES 89-653). p. 259; and (1990 – 1991): Snyder (NCES 93-292). pp. 276 and 277.

Note: This table supports Figure 2-17 in the text.

[a] Foreign student data by field first available in 1977.

Table C-9.

U.S. Doctorates Awarded to Foreign Students (by selected fields)
(in units and percentages of totals)

	1977[a]			1980			1985			1990			1991[b]		
	Total degrees awarded	Foreign students	Percentage	Total degrees awarded	Foreign students	Percentage	Total degrees awarded	Foreign students	Percentage	Total degrees awarded	Foreign students	Percentage	Total degrees awarded	Foreign students	Percentage
Life sciences	3,397	342	10.1	3,630	316	8.7	3,432	376	11.0	3,844	762	19.8	4,093	1,006	24.6
Physical sciences	3,341	532	15.9	3,122	509	16.3	3,269	682	20.9	4,164	1,326	32.7	4,290	1,433	33.4
Mathematics	823	160	19.4	729	168	23.1	699	249	35.6	917	473	51.6	978	514	52.6
Computer science	216	45	20.8	244	50	20.5	248	70	28.2	627	272	43.4	676	294	43.5
Engineering	2,586	847	32.8	2,534	912	36.0	3,230	1,398	43.3	4,981	2,507	50.3	5,272	2,735	51.9
Total doctorates awarded to foreign students in S&E	10,363	1,926	18.6	10,259	1,955	19.1	10,878	2,775	25.5	14,533	5,340	36.7	15,309	5,982	39.1

Sources: (1977 – 1985): Baker (NCES-653). pp. 225 and 249; and (1990 – 1991): Snyder (NCES 93-292). pp. 282 and 283.

Note: This table supports Figures 2-18 to 2-23 in the text.

[a] Foreign student data by field first available in 1977.

[b] Preliminary data.

Table C-10.

High School Completion at Age 28 to 29 (by race and ethnic group) (percentage of total subgroup population)

Subgroup	1975	1980	1985	1990[a]	1991[a]
White	86.8	90.0	89.0	90.7	89.7
Black (non-Hispanic)	69.0	77.8	83.8	79.5	85.2
Hispanic[b]	56.6	57.0	60.1	61.1	57.3
Total high school completions at age 28 to 29	83.6	86.3	86.0	86.4	86.1

Source: Alsalam, Nabeel, ed. *The Condition of Education: 1993.* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics (NCES 93-290), p. 253.

Note: This table supports Figure 2-24 in the text.

[a] Numbers for these years reflect new editing procedures instituted by the Bureau of the Census in 1986 for cases with missing data on school enrollment items.

[b] Persons of Hispanic origin may be of any race.

Table C-11.

Freshman Interest in Science and Engineering as Academic Majors (by year and selected field) (percentage of first-time, full-time enrollment)

Year	Computer science	Engineering	Physical sciences	Biological science	Mathematics	Total percent	Freshmen enrollment (000)[a]
1966	N/A	9.8	3.3	3.7	4.5	21.3	1,554
1967	N/A	9.5	3.0	3.7	4.2	20.4	1,641
1968	N/A	9.8	2.7	3.7	4.0	20.2	1,893
1969	N/A	10.2	2.5	3.3	3.5	19.5	1,967
1970	N/A	8.6	2.3	3.5	3.3	17.7	2,063
1971	N/A	7.2	2.0	3.6	2.7	15.5	2,119
1972	N/A	6.9	1.9	3.9	2.2	14.9	2,153
1973	N/A	6.6	2.7	7.0	1.7	18.0	2,226
1974	N/A	6.6	2.6	6.7	1.4	17.3	2,366
1975	N/A	7.9	2.7	6.3	1.1	18.0	2,515
1976	N/A	8.5	2.7	6.2	1.0	18.4	2,347
1977	N/A	9.3	2.3	4.7	0.8	19.9	2,394
1978	2.8	10.3	2.4	4.6	0.9	21.7	2,390
1979	3.5	10.6	2.3	4.0	0.6	21.5	2,503
1980	4.0	11.8	2.0	3.7	0.6	23.4	2,588
1981	5.3	12.0	2.1	3.7	0.6	25.3	2,595
1982	6.9	12.6	1.9	3.7	0.6	27.6	2,505
1983	8.8	11.7	1.8	3.8	0.8	26.6	2,444
1984	8.5	11.0	1.8	4.2	0.8	23.9	2,357
1985	6.1	10.7	1.6	3.4	0.7	20.8	2,292
1986	4.4	10.9	1.7	3.9	0.7	20.7	2,219
1987	2.7	9.4	1.6	3.8	0.6	18.1	2,246
1988	2.8	9.5	1.5	3.7	0.6	18.1	2,376
1989	2.6	10.2	1.6	3.7	0.6	18.7	2,353
1990	2.6	9.6	1.7	3.7	0.7	18.3	2,257
1991	2.4	10.1	1.6	4.4	0.6	19.1	2,278
1992	2.3	9.2	1.8	5.3	0.6	19.2	2,186[b]
1993	2.5	8.7	2.0	5.6	0.5	19.3	N/A

Source: (1966 – 1987): Cooperative Institutional Research program (CIAP), Higher Education Research Institute, University of California, Los Angeles, CA; (1988 – 1993): Astin, Alexander W., et al. *The American Freshman: National Norms for Fall 1988, 1989, 1990, 1991, 1992, 1993.* Los Angeles, CA: University of California, Los Angeles, CA. Cooperative Institutional Research Program; and (freshman enrollment): Snyder (NCES 93-292). p. 183.

Note: Based on samples of students at two- and four-year U.S. colleges and universities. N/A = not available. This table supports Figures 2-25 and 2-26 in the text.

[a] Total first-time freshman fall enrollment in U.S. institutions of higher education.

[b] Preliminary estimate.

Table C-12.
Freshman Interest in Science and Engineering as Academic Majors (by year and selected field) (in thousands of students interested in each subject area)

Year	Computer science	Engineering	Physical sciences	Biological science	Mathematics	Total[a]	Freshmen enrollment (000)[b]
1966	N/A	152	51	57	70	331	1,554
1967	N/A	156	49	61	69	335	1,641
1968	N/A	186	51	70	76	382	1,893
1969	N/A	201	49	65	69	384	1,967
1970	N/A	177	47	72	68	365	2,063
1971	N/A	153	42	76	57	328	2,119
1972	N/A	149	41	84	47	321	2,153
1973	N/A	147	60	156	38	401	2,226
1974	N/A	156	62	159	33	409	2,366
1975	N/A	199	68	158	28	453	2,515
1976	N/A	199	63	146	23	432	2,347
1977	67	223	55	113	19	476	2,394
1978	84	246	57	110	22	519	2,390
1979	100	265	58	100	15	538	2,503
1980	137	305	52	96	16	606	2,588
1981	179	311	54	96	16	657	2,595
1982	220	316	48	93	15	691	2,505
1983	208	286	44	93	20	650	2,444
1984	144	259	42	99	19	563	2,357
1985	101	245	37	78	16	477	2,292
1986	78	242	38	87	16	459	2,219
1987	61	211	36	85	13	407	2,246
1988	64	226	36	88	14	428	2,376
1989	61	240	38	87	14	440	2,353
1990	59	217	38	84	16	413	2,257
1991	55	230	36	100	14	435	2,278
1992	50	201	39	116	13	422	2,186[c]

Source: *(1966 – 1987):* Cooperative Institutional Research program (CIRP), Higher Education Research Institute, University of California, Los Angeles, CA; *(1988 – 1993):* Astin, Alexander W., et al. *The American Freshman: National Norms for Fall 1988, 1989, 1990, 1991, 1992, 1993.* Los Angeles, CA: University of California, Los Angeles, CA. Cooperative Institutional Research Program; and (freshman enrollment): Snyder (NCES 93-292). p. 183.

Notes: N/A = not available. This table supports Figure 2-26.

[a] Detail may not add to totals due to rounding.

[b] Total first-time freshman fall enrollment in U.S. institutions of higher education.

[c] Preliminary estimate.

APPENDIX D

Legal Authorities Supporting DoD Science and Engineering Intervention Programs

Legal Authorities Supporting DoD Science and Engineering Intervention Programs

This appendix contains a listing of the principal statutes, public laws, regulations, directives, and instructions that provide the legal basis for the intervention programs included in this study. This compilation is based on responses to the Office of the Secretary of Defense from the Military Services and Defense Agencies operating the programs, as augmented by independent research. We believe the principal authorities are cited.

The statutes as contained in United States Code are listed first, followed by Public Laws. Regulations, directives, and instructions implementing the statutes and laws follow in the order of the cited intervention programs.

STATUTES

Title 5 United States Code — Government Organization and Employees

Chapter 41, Training

Section 4103. Establishment of Training Programs

This section provides basic authority for establishing training programs for civilian employees of the government, either in government facilities or in non-government facilities. Subsequent sections define non-government facilities, limitations on amount of training each employee may receive in non-government facilities, agreements to serve in government employment after completion of training, and the payment of resulting training expenses.

Title 10 United States Code — Armed Forces

1. **Chapter 101, Training Generally**

Section 2005. Advanced Education Assistance: Active Duty Agreement; Reimbursement Requirements

Advanced education assistance may be given to a member of the armed forces under a written agreement, requiring each person to: complete the agreed education, to serve on active duty for an agreed period, and to reimburse

the government for the cost of such education if the person fails to complete the specified period of active duty.

Section 2007. Limitation on Payment of Tuition for Off-duty Training or Education

Provides for payment of tuition for off-duty training or education, and limits the Secretary of a military department from paying more than 75 percent of the charges for such training or education. Some exceptions are included for certain training.

2. Chapter 103, Senior Reserve Officers' Training Corps

Section 2103. Eligibility for Membership

Provides rules for eligibility for membership in Senior Reserve Officers' Training Corps (ROTC). Senior ROTC is conducted at colleges and universities, as opposed to Junior ROTC programs at the high school level.

Section 2107. Financial Assistance Program for Specially Selected Members

Authorizes the Secretary of the military department to provide financial assistance to selected members of the Senior Reserve Officers' Training Corps, including tuition, fees, books, and laboratory expenses. This financial assistance normally takes the form of ROTC scholarships.

3. Chapter 111, National Defense Science and Engineering Graduate (NDSEG) Fellowships

Section 2191. Graduate Fellowships

Provides authority for the Secretary of Defense to award fellowships for pursuing graduate degrees in science, engineering or other fields of study so designated. Includes provisions for awarding such fellowships.

Section 2193. Science and Mathematics Education Improvement Program

Authorizes DoD to: (1) support undergraduate or graduate education in science and engineering disciplines critical to national security functions of DoD, subject to certain conditions; and (2) conduct programs to improve the mathematics and scientific knowledge and skills of elementary and secondary school students and teachers.

Section 2194. Education Partnerships

Authorizes education partnership agreements between defense laboratories and U.S. educational institutions for the purpose of encouraging and enhancing study in scientific disciplines at all levels of education.

Section 2195. Department of Defense Cooperative Education Program

Directs defense laboratories to establish cooperative education programs for undergraduate and graduate students, in association with U.S. colleges or universities.

4. **Chapter 139, Research and Development**

Section 2358. Research Projects

Provides that the Secretary of Defense or his designee may engage in basic and applied research projects that relate to military needs under contract or grants to educational or research institutions, private businesses, or other agencies of the United States.

Section 2360. Research and Development Laboratories: Contracts for Services of University Students

Provides authority to contract with university students for temporary or intermittent technical services at defense research and development laboratories.

5. **Chapter 403, United States Military Academy**

Section 4331 et seq. Enabling legislation for the U.S. Military Academy

6. *Chapter 603, United States Naval Academy*

Section 6951 et seq. Enabling legislation for the U.S. Naval Academy

7. **Chapter 605, United States Naval Postgraduate School**

Section 7041 et seq. Enabling legislation for the U.S. Naval Postgraduate School

8. **Chapter 901, Training Generally**

Section 9314. Enabling legislation for the United States Air Force Institute of Technology

9. **Chapter 903, United States Air Force Academy**

Section 9331 et seq. Enabling legislation for the U.S. Air Force Academy

Title 20 United States Code — Department of Education

1. Chapter 13, Financial Assistance to Local Education Agencies

Section 241. Education of Children Where Local Agencies Cannot Supply Facilities

Enabling legislation for DoD dependents' schools in the United States – authorizes the provision of public education to children residing on Federal property in cases where local education agencies cannot supply facilities.

2. Chapter 17, National Defense Education Act

Section 462. Number of Fellowships

Authorizes the numbers of fellowships to be awarded for study in graduate programs at institutions of higher education.

Section 463. Award of Fellowships and Approval of Institutions

Provides rules for awarding the fellowships and approving of the selected institutions.

3. Chapter 28, Higher Education Resources and Student Assistance Programs – Strengthening Historically Black Colleges and Universities

Section 1060. Congressional Findings and Purposes

Provides authority to fund HBCUs to strengthen the physical plants, financial management, academic resources, and endowments of same. It codifies Executive Order 12677 of 28 April 1989, which also provided for special assistance to science and technology, and providing for part-time and summer positions for graduates and undergraduates of HBCUs. This Executive Order revoked a previous Executive Order, 12320 of 15 September 1981, on the same subject.

Title 42 United States Code — The Public Health and Welfare

1. Chapter 16, National Science Foundation

Section 1869. Scholarships and Graduate Fellowships

Authorizes the National Science Foundation to award scholarships and graduate fellowships for study and research in the sciences or in engineering. Guidance is provided for selecting individuals.

Section 1885, (a),(b). Congressional statement of findings and declaration of policy respecting equal opportunities in science and engineering.

Authorizes support for increasing participation of women and minorities in science and engineering; for encouraging women to consider and prepare for careers in science and engineering; and to support activities to initiate research at minorities institutions.

PUBLIC LAWS

Public Law 91-441 — Armed Forces Appropriation Authorization Act, Fiscal Year 1971

Section 203(a)

"Funds authorized for appropriation to the Department of Defense under the provisions of this or any other Act shall not be available after December 31, 1970, for payment of independent research and development or bid and proposal costs unless the work for which payment is made has, in the opinion of the Secretary of Defense, a potential relationship to a military function or operation . . .."

Section 204

"None of the funds authorized to be appropriated to the Department of Defense by this or any Act may be used to finance any research project or study unless such project or study has, in the opinion of the Secretary of Defense, a potential relationship to a military function or operation."

These sections limit research projects or studies by DoD to military functions or operations, and are often referred to the "Mansfield Amendment," after Senator Mike Mansfield of Montana, who proposed it in 1970.

Public Law 91-648 — Intergovernmental Personnel Act of 1970 — Training and Developing State and Local Employees

Section 1741 et seq.

Provides means to strengthen the training and development of state and local government employees and officials, particularly in professional, administrative, and technical fields through funding for training, development, and fellowship.

Public Law 95-561 — Defense Department's Education Act of 1978

Establishes the defense dependents' education system to provide public education for dependents of military or DoD civilian personnel stationed in overseas areas.

Public Law 101-189 — National Defense Authorization Act, Fiscal Years 1990 and 1991

Section 843. Scientific and Technical Education

(b) Sense of Congress. "In light of the findings in subsection (a), it is the sense of Congress that the Secretary of Defense should take such actions as may be necessary and appropriate to promote and encourage, at pre-college through post-doctoral levels, an increase in the number of citizens and nationals of the United States who pursue courses of study in science, engineering, and other technical disciplines."

Public Law 101-510 — National Defense Authorization Act for Fiscal Year 1991

Section 832.

Provides authority and direction to provide infrastructure assistance to historically Black colleges and universities and to other minority institutions.

Paragraph 2192. Science, Mathematics, and Engineering Education

(a) "The Secretary of Defense, in consultation with the Secretary of Education, shall, on a continuing basis —

(1) Identify actions which the DoD may take to improve education in the scientific, mathematics, and engineering skills necessary to meet the long-term national defense needs of the United States for personnel proficient in such skills; and

(2) Establish and conduct programs to carry out such actions."

IMPLEMENTING REGULATIONS AND DIRECTIVES

Pre-College

S&E Interest Programs

These programs include the Science and Engineering Fairs, Junior Science and Humanities Symposia, Uninitiates Introduction to Engineering, Minorities in Engineering program, and similar programs. They are funded annually on a recurring basis. The Military Service program managers, when asked for specific program authorities, referred to various statutes, regulations and instructions. Upon examination the cited references do not seem specifically to cover these activities. The ultimate authority in law for programs of this kind is therefore obscure.

Apprenticeship and Summer Work Programs

Title 5, U.S.C., Chapter 41

Title 10, U.S.C., Chapter 139

Code of Federal Regulations, Title 5, Part 213, Section 3102(q),(v),(w). [5 C.F.R. 213.3102(q)(v)(w)]

Federal Personnel Manual, Chapter 308, "Student Employment Programs," Subchapters 3,6,7,9

DoD Directive 1400.25-M, *Civilian Employee Training*, CPM Chapter 410, "Training," 1 October 1985

DoD Instruction 3218.1, *DoD Science and Apprenticeship Program for High School Students*, 29 July 1981

Reserve Officers Training Corps (ROTC)

Title 10 U.S.C., Chapter 103

Cooperative Education Training Programs (COOP)

Title 5 U.S.C., Chapter 41

Code of Federal Regulations, Title 5, Part 213, Section 3202. (5 C.F.R. 213.3202)

Federal Personnel Manual, Chapter 308, "Student Employment Programs," Subchapter 2

DoD Directive 1400.25-M, *Civilian Employee Training*, CPM Chapter 410, "Training," 1 October 1985

Summer Employment

Title 5 U.S.C., Chapter 31

Code of Federal Regulations, Title 5, Part 312, Section 3101. (5 C.F.R. 213.3101)

Federal Personnel Manual, Chapter 308, "Student Employment Programs," Subchapters 3,6,7,9

Federal Personnel Manual, Chapter 332, "Recruitment and Selection Through Competitive Examination," Appendix J, Summer Employment Program (FPM 332, Appendix J)

DoD Directive 1400.25-M, *Civilian Employee Training*, CPM Chapter 410, "Training," 1 October 1985

Undergraduate Programs

Undergraduate Study Programs (In-Service)

Title 5 U.S.C., Chapter 41, "Training"

Code of Federal Regulations, Title 5, Part 410, "Training," (5 C.F.R. 410)

Federal Personnel Manual, Chapter 410, "Training"

DoD Directive 1400.25-M, *Civilian Employee Training*, CPM Chapter 410, "Training," 1 October 1985

Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) Support Programs

Title 10 U.S.C., Chapter 139, "Research and Development"

Title 20 U.S.C., Chapter 28, "Strengthening Historically Black Colleges and Universities," Section 1060

Title 42 U.S.C., Chapter 16, "National Science Foundation," Section 1885

Executive Order 12677, "Historically Black Colleges and Universities"

DoD Directive 1440.1, *The DoD Civilian Equal Employment Opportunity (EEO) Program*, 21 May 1987

Graduate Programs

Graduate Study Programs (In-Service)

Same as for Undergraduate Study

Grants

Title 10 U.S.C., Chapter 139, "Research and Development"

Same as for HBCU/MI Support Programs

Federal Personnel Manual, Chapter 309, "Hosting Enrollees of Federal Grant Programs (FPM 309)"

Summer Employment

Same as for summer employment of undergraduate students

Cooperative Education Programs (COOP)

Same as for COOP programs for undergraduate students

Research Programs

Title 10 U.S.C., Chapter 139, "Research and Development"

Fellowships

Title 10 U.S.C., Chapter 111, "National Defense Science and Engineering Graduate" (NDSEG) Fellowships

Title 10 U.S.C., Chapter 139, "Research and Development"

Title 20 U.S.C., Chapter 17, "National Defense Education Act"

Title 42 U.S.C., Chapter 16, "National Science Foundation"

Postdoctoral/Faculty Programs

Research Programs

Public Law 91-648, Intergovernmental Personnel Act of 1970

Same as for Graduate Students

Fellowships

Same as for Graduate Students

APPENDIX E

DoD Scientist and Engineer Inventory

DoD Scientist and Engineer Inventory

The primary objective of this appendix is to display the inventory of active military and DoD civilian employees having science and engineering skills. There are four annexes:

- Annex E-1 – An inventory of DoD scientists and engineers as of 30 September 1990.
- Annex E-2 – An inventory of DoD scientists and engineers for the even years 1980 to 1990 and the resulting changes by broad fields of expertise.
- Annex E-3 – A comparison of Federal civilian job occupational groups and series, used widely to define the terms "scientist" and "engineer" by three Government agencies: the Office of Personnel Management, the National Science Foundation, and the Office of the Secretary of Defense. We have also included for comparison an additional listing of job codes developed by LMI during the course of this project.
- Annex E-4 – A description of the DoD Military/Civilian Master Crosswalk developed by Booz-Allen & Hamilton for DoD. This crosswalk was used to select military occupational skills comparable to the Office of Personnel Management (OPM) job occupational groups and series.

A short discussion of the contents of each annex proceeds the included information. There are some omissions and discrepancies in taxonomies used to determine the reported inventories and these are discussed in the annexes. As a result of these problems, these data must be considered preliminary. In the future, some of these problems can be resolved and a somewhat refined set of data obtained from DMDC. It is unlikely, however, that agreement will be reached in the foreseeable future on the precise definition of "scientists and engineers."

In the meantime, the data shown contain the major portion of the DoD scientist and engineer inventory. We have included all the specific job skills of primary interest to DoD policymakers at this time.

ANNEX E-1

DoD Scientist and Engineer Inventory
30 September 1990

DoD Scientist and Engineer Inventory 30 September 1990

Table E-1-1 reflects the current inventory of active military and DoD civilian personnel having science and engineering skills as of 30 September 1990. The compilation was obtained from the files of the Defense Manpower Data Center, using Office of Personnel Management (OPM) job occupational groups and series code numbers.

Military occupational codes for officers were connected to matching civilian job codes by use of DoD Military/Civilian Master Crosswalk prepared by Booz-Allen & Hamilton for DoD. This crosswalk is described in Annex 4.

The Military Services did not review the military codes; while the civilian codes do not agree fully with codes used by the National Science Foundation and the Office of the Secretary of Defense. As a consequence, these data must be considered preliminary.

Table E-1-1.
DoD Scientists and Engineer Inventory (30 September 1990)

Broad Academic Field	OPM job code[a]	Field of study	Military	Civilian	Total
Scientists					
Physical and Environmental Sciences	GS-1301	General Physical Science	276	2,132	2,408
	GS-1306	Health Physics	0	286	286
	GS-1310	Physics	317	2,822	3,139
	GS-1313	Geophysics	285	152	437
	GS-1315	Hydrology	0	68	68
	GS-1320	Chemistry	128	2,018	2,146
	GS-1321	Metallurgy	0	178	178
	GS-1330	Astronomy & Space Science	1	140	141
	GS-1340	Meteorology	1,302	286	1,588
	GS-1350	Geology	0	337	337
	GS-1360	Oceanography	0	388	388
	GS-1370	Cartography	998	3,370	4,368
	GS-1372	Geodesy	0	203	203
	GS-1373	Land Surveying	0	14	14
	GS-1380	Forest products Technology	0	1	1
	GS-1382	Food Technology	0	49	49
	GS-1384	Textile Technology	0	67	67
	GS-1386	Photographic Technology	0	32	32
		Subtotal	3,307	12,543	15,850

[a] Office of Personnel Management job occupational group and series code numbers.

Source: Defense Manpower Data Center.

Table E-1-1.
DoD Scientists and Engineer Inventory (30 September 1990) (Continued)

Broad Academic Field	OPM job code	Field of study	Military	Civilian	Total
Life Sciences	GS-0401	General Biology Science	385	1,012	1,397
	GS-0403	Microbiology	117	290	407
	GS-0405	Pharmacology	1	42	43
	GS-0406	Agriculture Extension	0	1	1
	GS-0408	Ecology	274	129	403
	GS-0410	Zoology	0	7	7
	GS-0413	Physiology	205	157	362
	GS-0414	Entomoloyg	120	61	181
	GS-0415	Toxicology	0	19	19
	GS-0430	Botany	0	12	12
	GS-0434	Plant Pathology	0	0	0
	GS-0435	Plant Physiology	0	0	0
	GS-0436	Plant Protection & Quarantine	0	9	9
	GS-0437	Horticulture	0	1	1
	GS-0440	Genetics	0	9	9
	GS-0454	Range Conservation	0	1	1
	GS-0457	Soil Conservation	0	12	12
	GS-0460	Forestry	0	18	18
	GS-0470	Soil Science	0	134	134
	GS-0471	Agronomy	0	6	6
	GS-0475	Agriculture Management	0	45	45
	GS-0480	General Fish & Wildlife Administration	0	23	23
	GS-0482	Fishery Biology	0	34	34
	GS-0485	Wildlife Refuge Management	0	0	0
	GS-0486	Wildlife Biology	0	78	78
	GS-0487	Animal Science	0	3	3
	GS-0493	Home Economics	0	15	15
		Subtotal	1,102	2,109	3,211

[a] Office of Personnel Management job occupational group and series code numbers.

Source: Defense Manpower Data Center.

Table E-1-1.
DoD Scientists and Engineer Inventory (30 September 1990) (Continued)

Broad Academic Field	OPM job code[a]	Field of study	Military	Civilian	Total
Mathematics and Computer Science	GS-0334	Computer Specialist	3,142	27,521	30,663
	GS-1510	Actuary	0	9	9
	GS-1515	Operations Research	2,531	3,479	6,010
	GS-1520	Mathematics	954	1,984	2,938
	GS-1529	Mathematical Statistician	7	134	141
	GS-1530	Statistician	13	157	170
	GS-1540	Cryptography	5	0	5
	GS-1550	Computer Science	6,807	2,483	9,290
		Subtotal	13,459	35,767	49,226
Social Sciences	GS-0020	Community Planning	0	224	224
	GS-0028	Environmental Protection Specialist	578	792	1,370
	GS-0101	Social Science	18	1,465	1,483
	GS-0110	Economist	0	326	326
	GS-0135	Foreign Agricultural Affairs	0	0	0
	GS-0150	Geography	0	98	98
	GS-0180	Psychology	700	1,188	1,888
	GS-0184	Sociology	0	11	11
	GS-0190	General Anthropology	0	16	16
	GS-0193	Archeology	0	105	105
		Subtotal	1,296	4,225	5,521

[a] Office of Personnel Management job occupational group and series code numbers.

Source: Defense Manpower Data Center.

Table E-1-1.
DoD Scientists and Engineer Inventory (30 September 1990) (Continued)

Broad Academic Field	OPM job code	Field of study	Military	Civilian	Total
Engineers and Architects	GS-0801	General Engineering	6,651	12,431	19,082
	GS-0803	Safety Engineering	477	379	856
	GS-0804	Fire Prevention Engineering	0	74	74
	GS-0806	Materials Engineering	0	908	908
	GS-0807	Landscape Architecture	0	172	172
	GS-0808	Architecture	1,748	1,136	2,884
	GS-0810	Civil Engineering	5,769	9,618	15,387
	GS-0819	Environmental Engineering	0	1,195	1,195
	GS-0830	Mechanical Engineering	675	11,938	12,613
	GS-0840	Nuclear Engineering	459	2,610	3,069
	GS-0850	Electrical Engineering	25	3,003	3,028
	GS-0855	Electronics Engineering	4,675	25,581	30,256
	GS-0858	Biomedical Engineering	64	54	118
	GS-0861	Aerospace Engineering	4,500	4,775	9,275
	GS-0871	Naval Architecture	104	1,190	1,294
	GS-0880	Mining Engineering	0	1	1
	GS-0881	Petroleum Engineering	2	4	6
	GS-0890	Agricultural Engineering	0	0	0
	GS-0892	Ceramic Engineering	0	28	28
	GS-0893	Chemical Engineering	1	951	952
	GS-0894	Welding Engineering	15	86	101
	GS-0896	Industrial Engineering	315	2,967	3,282
	GS-1221	Patent Advisor	0	20	20
	GS-1223	Patent Classifying	0	0	0
	GS-1225	Patent Interference Examining	0	78	78
	GS-1226	Design	0	15	15
		Subtotal	25,480	79,121	104,601

[a] Office of Personnel Management job occupational group and series code numbers.

Source: Defense Manpower Data Center.

Table E-1-1.
DoD Scientists and Engineer Inventory (30 September 1990) (Continued)

Broad Academic Field	OPM job code[a]	Field of study	Military	Civilian	Total
Health Care Professionals	GS-0601	General Health Science	296	156	452
	GS-0602	Medical Officer	10,745	1,347	12,092
	GS-0660	Pharmacist	581	540	1,121
	GS-0662	Optometrist	464	41	505
	GS-0665	Speech Pathology & Audiology	126	166	292
	GS-0668	Podiatrist	97	13	110
	GS-0680	Dentist	4,240	67	4,307
	GS-0690	Industrial Hygiene	0	551	551
	GS-0696	Consumer Safety	0	0	0
	GS-0701	Veterinary Medical Science	448	21	469
		Subtotal	16,997	2,902	469
Scientists					
Physical and Environmental Sciences			3,307	12,543	15,850
Life Sciences			1,102	2,109	3,211
Mathematics and Computer Science			13,459	35,767	49,226
Social Sciences			1,296	4,225	5,521
		Subtotal, Scientists	19,164	54,644	73,808
Engineers & Architects			25,480	79,121	104,601
Health Care Professionals			16,997	2,902	19,899
		Total Scientists & Engineers	61,641	136,667	198,308
		Grand Total		198,308	

[a] Office of Personnel Management job occupational group and series code numbers.

Source: Defense Manpower Data Center.

ANNEX E-2

Inventory of DoD Scientists and Engineers — Changes, 1980 to 1990

Inventory of DoD Scientists and Engineers — Changes, 1980 to 1990

Table E-2-1 displays the number of scientists and engineers employed by the DoD in military and civilian positions for the even years from 1980 to 1990. During that period, the numbers of scientists and engineers in DoD increased by nearly 62,000, or 45.5 percent. This equates to an annual rate of increase of approximately 6,200 scientists and engineers, or a growth of 4.5 percent per year.

Not all categories of scientists and engineers increased at the same rate, however. The number of physical scientists and health care professionals remained virtually constant over the period, with the mathematics and computer science fields showing the largest growth.

When health care professionals are excluded from the inventory, there still are approximately 178,000 olther scientists and engineers in the DoD. That is a much greater quantity than the most recent DoD estimate of 127,000 military and civilian scientists and engineers that was given to Congress in March of 1990. If the existing differences, disagreements, and omissions occurring among the S&E lists of Appendix E, Annex 3 were resolved, there would be an even larger inventory of DoD scientists and engineers.

Table E-2-1.
DoD Scientist and Engineer Inventories: 1980 to 1990 (military and civilian)

Broad Academic Field	Year						
	1980	1982	1984	1986	1988	1990	Percent change: 1980 to 1990
Scientists							
Physical and Environmental Sciences	15,843	15,956	16,665	16,873	16,365	15,850	+ 0.04
Life Sciences	2,264	2,438	2,606	2,958	3,067	3,211	+ 41.83
Mathematics and Computer Science	27,405	31,021	35,089	46,121	49,215	49,226	+ 79.62
Social Sciences	3,097	3,522	3,776	4,351	4,758	5,521	+ 78.27
Subtotal Scientists	48,609	52,937	58,136	70,303	71,405	73,808	+ 51.84
Engineers and Architects	67,716	74,109	83,136	96,581	101,995	104,601	+ 54.47
Health Care	20,061	20,742	21,138	21,512	19,439	19,899	- 0.81
Total Scientists and Engineers	136,386	147,770	162,410	188,396	192,839	198,308	+ 45.40

Source: Defense Manpower Data Center.
Note: Numbers shown include both military and civilian personnel.

ANNEX E-3

Comparison of Federal Civilian Scientist and Engineering Job Occupational Groups and Series

Comparison of Federal Civilian Scientist and Engineering Job Occupational Groups and Series

Table E-3-1 compares four different sets of civilian scientists and engineering job occupational groups and series. Both the Office of Personnel Management and the National Science Foundation publish "official" taxonomies of the particular job skills that they define as "scientist and engineer." These are reflected in the first two columns and identify differences between the lists of the agencies. In the course of this work, we have suggested to both the OPM and the NSF staffs that reconciliation be begun. We were encouraged by their limited responses.

The Office of Personnel Management controls Federal job classification. That would seem to make OPM preeminent in determining what Federal jobs require to be filled by scientists or engineers. The National Science Foundation, in preparing its statistical tables showing "Federal scientists and engineers," uses data provided by OPM.

The NSF taxonomy and the OPM taxonomy are not consistent, as shown by comparing the first two columns in Table E-3-1. Most of the disagreements are not substantitve, but there are a few significant differences. The NSF does not include history, social work, or landscape architecture as part of the S&E taxonomy, for example, even though OPM does.

There are also differences in the treatment of certain job skills related to the patent process. Discussions with representatives of the United States Patent Office, Department of Commerce, indicated that all of the six different patent job skills utilized there require engineering degrees as prerequisites for those positions. We believe that NSF should include these skills in their S&E taxonomy.

The job of computer specialist (OPM job code 0334) is another problem. The NSF counts it as an S&E skill but OPM does not. The OPM staff concurs with a need for realignment and intends to follow the NSF lead in listing this skill within the S&E group.

The NSF does not include cryptography (OPM job code 1540) for the simple reason that there are not many persons in this skill. There were five Federal civilians classified in this job skill in 1990. We note, however, that several job skills have fewer than five [such as *petroleum engineering* (1) and *agriculture engineering* (4)]. It seems unreasonable to exclude *cryptography.*

A major difference between the practices of the two agencies exists in the handling of health care professionals. OPM includes them and NSF does not. The argument of NSF is that they have nothing to do with funding activities in the health care field. That is the responsibility of the National Institutes of Health. Most health care professionals receive instruction in many scientific fields, however. In many cases they actually conduct research after completing, say, a medical or nursing education. Those professionals do not deliver health care to the public. We believe that the best national lists of scientific and engineering positions should include those included in the health care professions.

Table E-3-1 also shows in columns three and four, a comparison between lists of scientist and engineering job skills used by the Office of the Secretary of Defense and by the authors. The OSD list was given to LMI at the beginning of this study. The LMI list was sent to the Defense Manpower Data Center to obtain the longitudinal data required for Tables E-1-1 and E-2-1. The latter list includes some changes (based on experience) from the OSD list, but even the LMI list is probably incomplete.

As a result of the above differences and discrepancies, the data included in this appendix must be considered preliminary. We believe that a resolution of the described differences should be sought. Refined data can then be obtained from DMDC.

Table E-3-1.
Comparison of Federal Civilian Scientist and Engineering Job Occupational Groups and Series

OPM[a] job code	Field of study	OPM[b]	NSF[c]	OSD[d]	LMI[e]
	Scientists				
	Physical and Environmental Sciences				
1301	General physical sciences	●	●	●	●
1306	Health Physics	●	●	●	●
1310	Physics	●	●	●	●
1313	Geophysics	●	●	●	●
1315	Hydrology	●	●	●	●
1320	Chemistry	●	●	●	●
1321	Metallurgy	●	●	●	●
1330	Astronomy and space science	●	●	●	●
1340	Meteorology	●	●	●	●
1350	Geology	●	●	●	●
1360	Oceanography	●	●	●	●
1370	Cartography	●	●	●	●
1372	Geodosy	●	●	●	●
1373	Land surveying	●	●		●
1380	Forest products technology	●	●	●	●
1382	Food technology	●	●	●	●
1384	Textile technology	●	●	●	●
1386	Photographic technology	●	●	●	●
	Life Sciences				
0401	General biological science	●	●	●	●
0403	Microbiology	●	●	●	●
0405	Pharmacology	●	●	●	●
0406	Agricultural extension	●	●		●
0408	Ecology	●	●	●	●
0410	Zoology	●	●	●	●
0413	Physiology	●	●	●	●
0414	Entomology	●	●	●	●
0415	Toxicology	g	●		●
0430	Botany	●	●	●	●
0434	Plant pathology	●	●	●	●
0435	Plant physiology	●	●	●	●
0436	Plant protection and quarantine	●	●	●	●
0437	Horticulture	●	●	●	●

Note: See footnotes at the end of the table.

Table E-3-1.
Comparison of Federal Civilian Scientist and Engineering Job Occupational Groups and Series (Continued)

OPM[a] job code	Field of study	OPM[b]	NSF[c]	OSD[d]	LMI[e]
	Life Sciences (continued)				
0438	Genetics	●	●	●	●
0454	Range conservation	●	●	●	●
0457	Soil conservation	●	●	●	●
0460	Forestry	●	●	●	●
0470	Soil science	●	●	●	●
0471	Agronomy	●	●	●	●
0475	Agriculture management	●	●		●
0480	General fish and wildlife administration	●	●	●	●
0482	Fishery biology	●	●	●	●
0485	Wildlife refuge management	●	●	●	●
0486	Wildlife biology	●	●		●
0487	Animal science	●	●	●	●
0493	Home economics	●	f	●	●
	Mathematics and Computer Science				
0334	Computer specialist	g	●		●
1510	Actuary	●	●	●	●
1515	Operations research	●	●	●	●
1520	Mathematics	●	●	●	●
1529	Mathematics statistician	●	●	●	●
1530	Statistician	●	●	●	●
1540	Cryptography	●	h	●	●
1550	Computer science	●	●	●	●
	Social Sciences				
0020	Community planning	●	●		●
0028	Environmental science	g	f		●
0101	Social science	●	●	●	●
0110	Economist	●	●		●
0135	Foreign agriculture affairs	g	●		●
0140	Manpower research and analysis	●	f		●
0150	Geography	●	●	●	●
0170	History	●	i		
0180	Psychology	●	●	●	●
0184	Sociology	●	●	●	●

Note: See footnotes at the end of the table.

Table E-3-1.
Comparison of Federal Civilian Scientist and Engineering Job Occupational Groups and Series (Continued)

OPM[a] job code	Field of study	OPM[b]	NSF[c]	OSD[d]	LMI[e]
	Social Sciences (continued)				
0185	Social Work	●	i		
0190	General anthropology	●	●	●	●
	Engineers and Architects				
0193	Archaeology	●	●	●	●
0801	General engineering	●	●	●	●
0803	Safety engineering	●	●	●	●
0804	Fire prevention engineering	●	●	●	●
0806	Materials engineering	●	●	●	●
0807	Landscape architecture	●	i	●	●
0808	Architecture	●	●	●	●
0810	Civil engineering	●	●	●	●
0819	Environmental engineering	●	●	●	●
0830	Mechanical engineering	●	●	●	●
0840	Nuclear engineering	●	●	●	●
0850	Electrical engineering	●	●	●	●
0854	Computer engineering	●	i		
0855	Electronics engineering	●	●	●	●
0858	Biomedical engineering	●	●	●	●
0861	Aerospace engineering	●	●	●	●
0871	Naval architecture	●	●	●	●
0880	Mining engineering	●	●	●	●
0881	Petroleum engineering	●	●	●	●
0890	Agricultural engineering	●	●	●	●
0892	Ceramic engineering	●	●	●	●
0893	Chemical engineering	●	●	●	●
0894	Welding engineering	●	●	●	●
8096	Industrial engineering	●	●	●	●
1220	Patent administration	●	i		
1221	Patent advisor	●	f	●	●
1223	Patent classifying	●	i	●	●
1224	Patent examining	●	i		
1225	Patent interference examining	●	i	●	●
1229	Design patent examining	●	f	●	●

Note: See footnotes at the end of the table.

Table E-3-1.
Comparison of Federal Civilian Scientist and Engineering Job Occupational Groups and Series (Continued)

OPM[a] job code	Field of study	OPM[b]	NSF[c]	OSD[d]	LMI[e]
	Health Care Professionals				
0601	General health science	●	i		●
0602	Medical officer	●		●	●
0610	Nurse	●			
0630	Dietician and nutritionist	●			
0631	Occupational therapist	●			
0633	Physical therapist	●			
0635	Corrective therapist	●			
0637	Manual arts therapist	●			
0638	Recreation/creative arts therapist	●			
0639	Educational therapist	●			
0644	Medical technologist	●			
0660	Pharmacist	●		●	●
0662	Optometrist	●		●	●
0665	Speech pathologist and audiologist	●		●	●
0668	Podiatrist	●		●	●
0680	Dental officer	●		●	●
0690	Industrial hygiene	●		●	●
0696	Consumer safety	●		●	●
0701	Veterinary medical science	●		●	●

[a] Occupational group and series job codes used by the Office of Personnel Management for classifying federal civilian employees.

[b] Office of Personnel Management (OPM) list of Scientist and Engineer job codes as published in *Handbook of Occupational Groups and Series*. Washington, DC: Office of Classification, 1989.

[c] National Science Foundation (NSF) list of federal civilian employee job occupational group and series as published in "National Science Foundation, Surveys of Science Resource Series, *Federal Scientists and Engineers*: 1988, (NSF 89-322), Washington, DC.

[d] Office of the Secretary of Defense (OSD) list of Scientist and Engineer job codes provided to LMI at the initiation of this study.

[e] Federal Civilian Scientist and Engineer job codes used by LMI to obtain longitudinal data from the Defense Manpower Data Center on DoD scientist and engineer employment in DoD from 1981 to 1990.

[f] Discussions with Mr. John Tsapogas at the National Science Foundation indicated that they agree that these job skills should be included in their scientist and engineer taxonomy.

[g] Discussions with Mr. Philip Schneider at the National Science Foundation indicated that they agree that these job skills should be included in their scientist and engineer taxonomy.

[h] Discussions with Mr. John Tsapogas at the National Science Foundation indicated that they exclude this job skill because of the small numbers involved.

[i] Discussions with Mr. John Tsapogas at the National Science Foundation indicated that they do not believe these job skills should be included in their scientist and engineering taxonomy.

[j] Discussions with Mr. John Tsapogas at the National Science Foundation indicated that they do not include Health Care Professionals as scientists and engineers because they do not fund programs in these fields. They are the responsibility of the National Institutes of Health.

ANNEX E-4

DoD Military/Civilian Master Crosswalk

DoD Military/Civilian Master Crosswalk

In the early 1980's, the Office of the Assistant Secretary of Defense (Force Management and Personnel/Accession Policy) began an effort, using Booz-Allen & Hamilton of Bethesda, Maryland, to create a crosswalk between the federal civilian job codes and military specialty or occupational job codes.

The first step in this project consisted of matching military occupational codes (MOCs) with U.S. Department of Labor's *Dictionary of Occupational Titles* (DOT) codes. Then the MOC's were linked to other civilian job code taxonomies, including the OPM job code series. These relationships were established through an initial linkage via mutual DOT codes.

The resulting DoD Military/Civilian linkages are now maintained in a "Master Crosswalk" file at the Defense Manpower Data Center (DMDC), Monterey, California. This master crosswalk was used by Booz-Allen at the request of LMI and with the permission of the Accession Policy office to create a list of MOCs that was representative of DoD scientist and engineering skills provided by OSD for this study.

The basis for selecting OPM and MOC codes, through the DOT linkage, was the similarity of tasks performed in the military and civilian occupations. Analysts compared the standardized definitions for civilian occupations contained in the DOT with definitions that each Service had developed for its military occupations. In judging equivalency of selected skills, analysts applied an ideal referred to as the "two-way test." That is, they estimated whether fully qualified workers in the civilian occupation could perform the essential tasks of the military occupation after receiving orientation and equipment-specific training; and the reverse, whether fully qualified workers in the military occupation could perform the essential tasks of the civilian occupation after receiving only orientation and equipment-specific training.

The resultant linkages have several limitations. First, some MOCs state that a degreed scientist or engineer is "desirable" to fill the position, but not required. This feasibility creates some difficulty in making specific links. Second, Navy Officer Billet Codes are assigned to billets (jobs or positions), not to officers. As a result, we assumed that the incumbent in the billet has the qualifications of the billet code; this assumption is not always valid, however.

Third, the differences among the NSF, OPM, and OSD taxonomies for federal civilian scientists and engineers (see Annex E-3 of this Appendix), it is expected that there would also be inconsistencies in some of the MOCs.

Finally, the Military Services have not had an opportunity to review the list of MOCs for accuracy. Therefore, we must assume that the resulting list of MOCs based on the DoD Military/Civilian Master Crosswalk is only preliminary. A future effort should be made to review these MOCs and assure that they are representative of those military occupational skills requiring degreed scientists or engineers.

APPENDIX F

Retention of Cooperative Education Program Hires Versus Direct Hires

Retention of Cooperative Education Program Hires Versus Direct Hires

This appendix examines the retention rate of two types of employees hired as new journeymen (GS-5/9) scientists and engineers at the Naval Air Development Center (NADC), Warminster, Pennsylvania, during the period FY 1985 through FY 1990.

NADC has a fairly large Cooperative Education Program (COOP) that attracts new baccalaureate and masters degree scientists and engineers to seek full-time employment in their laboratories. To fulfill their total employment needs for scientists and engineers, NADC also goes directly to the marketplace with normal recruiting practices to fill the remainder of its vacancies.

During the period from FY 1985 through FY 1990, NADC hired 412 new journeyment scientists and engineers: 125 COOP graduates and 287 direct hires. Table F-1 shows a comparison of retention data for the two groups of employees by year of employment. For each group, Table F-1 provides the number hired, the average number of years the employees remained on the NADC payroll, and the percentage that remained on the payroll for the entire period after being hired.

To illustrate the use of the table, NADC hired, in FY 1985, 25 scientists and engineers through COOP and another 139 directly. The COOP graduates stayed an average of 5.44 years (out of the maximum 6 years from FY 1985 through FY 1990), while the direct-hire employees stayed an average of 5.11 years. In addition, 73 percent of the COOP employees were still on the job in FY 1990, versus 62 percent of the direct-hire employees.

The retention rate of COOP graduates is higher for those employed in FY 1985, FY 1987, and FY 1989. In FY 1986, the retention rate of direct-hire personnel is higher, although the numbers of new employees hired that year is somewhat smaller than in other years. No direct-hire employees joined the NADC work force in FY 1988.

Based on these data it appears that COOP-developed employees may elect to remain Government employees for longer periods of time than those hired directly in the marketplace. Of course, a number of related factors need to be examined before this assumption can be be proved.

Table F-1.
NADC Retention Experience with COOP and Direct Hire Scientists and Engineers

Program	Fiscal year hired					
	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
COOP						
Number hired	25	18	28	18	24	11
Average number of years employed	5.44	4.06	3.71	2.56	2.00	1.00
Percent remaining since hired	73%	56%	82%	72%	100%	100%
Direct hire						
Number hired	139	8	63	None	31	47
Average number of years employed	5.11	4.38	3.56		1.97	1.00
Percent remaining since hired	62%	75%	81%		97%	100%

Source: NADC staff.

APPENDIX G

The Department of Defense Report on Science and Engineering Education Activities of the Department of Defense

THE DEPARTMENT OF DEFENSE REPORT ON SCIENCE AND ENGINEERING EDUCATION ACTIVITIES OF THE DEPARTMENT OF DEFENSE

FOR THE COMMITTEES ON ARMED SERVICES
UNITED STATES CONGRESS

MARCH 1990

THE DEPARTMENT OF DEFENSE REPORT

ON

SCIENCE AND ENGINEERING EDUCATION ACTIVITIES

OF THE DEPARTMENT OF DEFENSE

FOR

THE COMMITTEES ON ARMED SERVICES

UNITED STATES CONGRESS

MARCH 1990

TABLE OF CONTENTS

INTRODUCTION

This report responds to Section 843 of Public Law 101-189, the National Defense Authorization Act for Fiscal Years 1990 and 1991, which requires the Secretary of Defense to submit a report on Science and Technology Education Programs in the DoD as follows:

(a) FINDINGS. - Congress makes the following findings:

(1) The possession and maintenance of technologically superior systems in the Department of Defense is a critical part of the national defense strategy of the United States.

(2) Defense programs use a significant portion of the entire science and technology workforce of the United States.

(3) The science and technology workforce of the United States has been declining in recent years and that decline threatens the supply of qualified engineers and scientists for the Department of Defense in the future.

(b) SENSE OF CONGRESS. - In light of the findings of subsection (a), it is the sense of Congress that the Secretary of Defense should take such actions as may be necessary and appropriate to promote and encourage, at precollege through post-doctoral levels, an increase in the number of citizens and nationals of the United States who pursue courses of study in science, engineering, and other technical disciplines.

(c) Report. - The Secretary of Defense shall submit to the Committees on Armed Services of the Senate and House of Representatives, by February 1, 1990, a report on current, expanded and proposed new programs of the Department of Defense and, as appropriate, proposed interagency programs to preserve and perpetuate an effective scientific and engineering workforce for the United States for the future. The Secretary, in coordination with the Director of the Office of Science and Technology Policy, shall include in the report an evaluation of the following concepts:

(1) Summer Internships at Department of Defense laboratories for precollege teachers of science, engineering, or other technical disciplines.

(2) An award program for exceptional precollege teachers in sciences, engineering or other technical disciplines.

(3) A scholarship program for undergraduates in scientific or technical education who plan to teach those disciplines at the precollege level.

(4) Expanding the Barry Goldwater Scholarship and Excellence in Education Program or any other such program that the Secretary and Director mutually agree would promote increases in scientific and engineering careers.

The report which follows is divided into four sections: Section I provides an overview; Section II describes existing DoD programs and examines the potential for expansion; Section III addresses program effectiveness, new programs and evaluates concepts requested by the Committees; and Section IV provides conclusions and recommendations. Appendix A provides a data base of programs, participation level and funding and Appendix B contains supplementary information collected independent of the survey responses.

SECTION I: SCIENCE AND ENGINEERING EDUCATION IN THE DEPARTMENT OF DEFENSE - AN OVERVIEW

As Congress stated in the findings, the Department of Defense relies heavily on a strategy of technological superiority to counter the numerical superiority of potential adversaries and is a major employer of scientists and engineers. The U.S. science and engineering work force totaled 4,626,500 in 1986 according to the last National Science Foundation survey (1). Fields included in this survey are physical scientists, mathematical scientists, computer specialists, environmental scientists, life scientists, psychologists, social scientists and engineers. The survey also indicated that 13 percent of that work force (600,000) was in defense related activity, (1). The Department of Defense directly employs approximately 127,000 civilian and military scientists and engineers (2) or 2.8 percent of the national pool. Of this number, approximately 100,000 are civilian employees of DoD of whom 25,000 are engaged in research and development in DoD laboratories and centers (2). The DoD, therefore, has a vital interest in the ability of our nation's colleges and universities to produce highly trained scientists and engineers.

A number of factors may impact DoD's future ability to recruit and retain qualified scientific and technical personnel. Chief among the concerns is changing demographics that will markedly affect the composition of the work force. This concern is most concisely addressed in the report, "Changing America: The New Face of Science and Engineering," prepared in 1988 by the interagency Task Force on Women, Minorities and the Handicapped in Science and Technology (3). The report notes in particular that by the year 2000, 85 percent of the increase in new entrants to the work force is projected to be women, minorities, handicapped persons and immigrants, groups which traditionally have tended to choose careers other than science and engineering.

A second cause for concern is the decline in the percentage of U. S. citizens pursuing science and engineering degrees and careers. The total number of scientists and engineers in the work force increased at a rate of approximately 7 percent per year between 1976 and 1986 (1), however much of this increase was composed of non-U.S. citizens who are ineligible for federal employment. Over the period 1974 to 1985, the number of B.Sc. degrees awarded in science and engineering increased by only 0.5 percent per year, the number of M.Sc. degrees increased by 1.1 percent per year, and the number of Ph.D.s actually decreased by 0.02 percent per year (4). While these figures appear rather low, the situation for citizens and nationals is even worse since the overall figures are obscured by the large number of foreign students in U.S. schools. For example, in 1986 75 percent of the graduate students receiving financial aid from university engineering departments were foreign students and 50 percent of Ph.D.s awarded were to foreign nationals. Most of these students,

because of commitments to return to their country of origin; lack of U.S. citizenship; or ineligibility for a security clearance, are not available to the Defense science and engineering work force.

Moreover, the total number of college freshmen pursuing degrees in science and engineering (S&E) has also been dropping over the past decade (although recently released figures from an American Association of Engineering Societies study show a 3 percent increase over the previous year for 1988, indicating a possible reversal of the trend for engineering). Even more distressing is the poor performance exhibited by U.S. students on standardized math and science tests at the precollege level when compared to their contemporaries in other industrialized countries.

The DoD is thus faced with, a) a flat to declining supply of U.S. citizens graduating from universities; b) an unfavorable demographic projection for the groups that have traditionally provided the largest numbers of scientists and engineers; c) a decrease in the quality of high school graduates; and d) an unfavorable pay structure to compete for the available people. The recruiting problem could become even more difficult if the present loss rate were exacerbated by a further deterioration in the civil service pay schedule relative to the private sector. This is a serious problem for a Department that relies heavily on advanced technology.

In our efforts to reverse the decline we are seeking to correct deficiencies in the compensation and benefit package for S&Es in civil service, to effect changes in training regulations to allow government employees to obtain either undergraduate or advanced degrees in science and engineering as part of a training program, to develop exploratory programs using the Department of Defense Dependents Schools (DODDS), and to develop a cost model to guide investment strategies in intervention programs.

While the DoD has a clear interest in and concern for maintaining an adequate supply of well-trained scientists and engineers, the courses of action selected to address this issue must be consistent with the mission and statutory authority of the DoD. The Department of Education and the National Science Foundation have a major mission and a clear mandate to develop and conduct programs in science and engineering education. The DoD mission is to provide for national security, and any education programs it conducts must be in direct support of that mission.

The DoD does make a major investment in education and training, spending over $32 billion a year to train 350,000 recruits; maintain technical skills of 750,000 technicians; conduct flight training for pilots; and support a host of other training activities to maintain a keen edge of operational readiness. In the more traditional educational setting, DoD provides education

for grades K through 12 for 200,000 dependents in overseas locations (DODDS) and in U.S. locations where the local civilian schools cannot meet the needs of the dependent population (Section 6). The Service Academies will graduate about 3,300 officers in 1990 and have a total enrollment of about 14,000. ROTC programs have an enrollment of about 87,000 with 21,740 on scholarships. Over 750,000 enlistees are participating in the Montgomery GI Bill plan which provides subsidies to assist them in completing their college educations. While these activities are representative of DoD education and training activities for military personnel, they are not primarily concerned with science and engineering education, and will not be considered further with the exception of the ROTC programs which do have a large science and engineering component.

Science and Engineering education activities in DoD are primarily centered around two functions: conducting research in support of national defense, and recruiting and retaining civilian employees in science and engineering career fields. The authority to conduct these activities comes from several sources including:

1. Section 2358 of Title 10 United States Code authorizes the Secretary of Defense to conduct basic and applied research that relates to weapons systems and other military needs by contract or grant to educational institutions. These contracts and grants also provide the funds for research assistantships for graduate students.

2. Chapter 41 of Title 5 United States Code authorizes training for government employees and assigns the Office of Personnel Management the responsibility to issue the necessary regulations for all Federal agencies. The regulations permit education and training to maintain and improve skills of government employees but do not permit the acquisition of a degree as the sole objective.

3. Executive Orders 12320 and 12677 direct Federal Departments and Agencies to support initiatives that will provide quality education at and increase the participation of Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) in Federal programs.

4. Section 2360 of Title 10 United States Code permits DoD research laboratories to contract with students or not-for-profit organizations for research services of the students on an intermittent basis.

5. Section 2191 of Title 10 United States Code establishes the National Defense Science and Engineering Graduate (NDSEG) Fellowship program.

6. Section 9111 of Public Law 101-165, Department of Defense Appropriations Act, 1990 directs the Secretary of Defense to "design a comprehensive strategy to involve civilian and military employees of the Department of Defense in Partnerships with elementary and secondary schools...." Such partnership programs enable DoD employees to serve as unpaid volunteers under the supervision of education professionals. This provides statutory authority for pre-college programs previously conducted under executive orders.

7. A few other specific programs have been authorized to address shortages in critical skill fields such as the Health Sciences University (100 medical students per year), the Defense Intelligence School (advanced training in fields related to intelligence), and the National Cryptologic School (for advanced training in cryptology and related fields).

8. DoD regulations also permit facilities and personnel to be used for community relations programs if the effort does not adversely impact the primary mission of the facility, thus permitting tours and mentor and tutoring programs.

Science and engineering education programs in the Department of Defense are thus conducted in support of the primary mission, providing for national defense. The fact that these programs are operated under diverse authorities and are intended to support diverse objectives of the Department (i.e. research, training, recruitment, etc.) means there is no centrally managed science and engineering education office, nor a centralized data base. Such segmentation and dispersal of management function serves the various communities well, and there is, nonetheless, good overall coordination. The Research program offices of the Services, Army Research Office (ARO); Office of Naval Research (ONR); and Air Force Office of Scientific Research (AFOSR), all administer similar research programs with the academic community but differ in the mix of science and engineering disciplines funded. The Service research programs are coordinated for the Secretary of Defense by the Office of Research and Laboratory Management. The DoD programs are also coordinated with other agencies such as National Science Foundation, Department of Energy, National Aeronautics and Space Administration, and National Institutes of Health to assure that stipends are comparable, policies are uniform, and common problems are recognized. The Personnel programs are coordinated by Office of Personnel Management for all Federal agencies in terms of the generic programs available, but each organization may emphasize different programs to fit its needs. Equal Employment Opportunity (EEO) guidelines are likewise established government-wide but the design of intervention programs to fit a local situation is left to the individual base or laboratory.

The tasking to survey programs for the purposes of this report was issued concurrently with the request to evaluate existing

programs and develop a plan for future expansion. The tasking letter was jointly signed by the Director of Defense Research and Engineering and the Assistant Secretary of Defense for Force Management and Personnel and was sent to the Military Departments and Defense Agencies. The information requested included a description of the program, program objectives, program history, performing organization, coordination, program evaluation and projection of future plans.

Responses to the tasking letter were received from the Defense agencies and the Departments listed in Table I. The responses were submitted in various levels of detail and compliance with the format requested. Information on programs administered by a central office tended to be fairly complete while information on programs operated at the local level were considerably less complete. Part of the difficulty lies in the fact that training programs that emphasize science and engineering are not normally distinguished from other training for management, finance, etc. Nonetheless, the information made available by the survey provides a fairly complete picture of the type of programs conducted and/or supported by the DoD and permits a reasonable assessment of the types of programs which are successful and merit continued support or expansion. However, the survey does not provide comprehensive details of the number of participants and the amount of funding across DoD for all of the programs.

TABLE I

COMPONENTS RESPONDING TO SURVEY

DEPARTMENT OF THE ARMY
- Assistant Secretary (Personnel)
  - Army Materiel Command
  - Army Corps of Engineers
- Army Research Office

DEPARTMENT OF THE NAVY
- Assistant Secretary (Civilian Personnel)
  - NAVAIR
  - NAVSEA
  - NAVFAC
  - NAVSPAWAR
- Office of Chief of Naval Research

DEPARTMENT OF THE AIR FORCE
- Air Force Civilian Personnel Management Center
- Air Force Office of Scientific Research

DEFENSE AGENCIES
- Defense Mapping Agency
- Defense Intelligence Agency
- Defense Nuclear Agency
- National Security Agency
- Strategic Defense Initiative Organization - No programs
- Defense Logistics Agency - No programs
- Defense Investigative Service - No programs
- Defense Contract Audit Agency - No programs

SECTION II: DESCRIPTION OF EXISTING PROGRAMS

The Department of Defense supports a wide variety of programs which involve science and engineering education either directly, such as fellowship support for students or tuition payments for employee training, or indirectly, such as work experience in DoD laboratories or by research performed on DoD grants to universities. The programs include all levels of education from pre-college to post-doctoral with the largest level of support at the graduate level. Programs described include both training for Department civilian employees and broader efforts to increase the supply of scientists and engineers. Science and technology education activities in the military which include the Service academies, Service post-graduate schools, technical training schools, and education programs for Service personnel are substantial activities but are not addressed in this report which deals with civilian science and engineering education. Likewise recruiting activities which have no component of education are not considered in this report.

Program descriptions of 112 discrete programs were received from the survey. These responses were categorized by the education level addressed, pre-college, undergraduate, graduate, and post-doctoral (including faculty). The programs were then further characterized by the primary purpose of the program which included: stimulation of career interest in science and technology; improvement of the quality of teaching; provision of experience in a laboratory setting; targeting of under-represented groups, such as women and minorities; fellowship support for other than employees; training programs to improve the knowledge and skills of government employees; and the performance of military research, which on the one hand provides new knowledge and on the other provides training at the early stages of a career or at career field changes. A tabulation of programs with information on the reporting component, unit at which the program is implemented, date the program was initiated, number of participants in 1989, support in 1989 in thousands of dollars, number of female participants and number of minority participants (including minority females) is provided in Appendix A. Unless specifically stated to the contrary, U.S. citizenship is a requirement to participate in these programs. A narrative description of each type of program is provided in the following section in accordance with the following outline:

PRE-COLLEGE LEVEL EDUCATION PROGRAMS

A. IMPROVE QUALITY OF SCIENCE EDUCATION
B. STIMULATE CAREER INTEREST
C. TARGETED PROGRAMS FOR WOMEN AND MINORITIES
D. EXPERIENCE PROGRAMS

UNDERGRADUATE LEVEL EDUCATION PROGRAMS

A. ROTC
B. EXPERIENCE PROGRAMS
C. TARGETED PROGRAMS
D. EMPLOYEE TRAINING

GRADUATE LEVEL EDUCATION PROGRAMS

A. FELLOWSHIPS
B. EXPERIENCE PROGRAMS
C. CONDUCT RESEARCH
D. EMPLOYEE TRAINING

POST-DOCTORAL AND FACULTY LEVEL EDUCATION PROGRAMS

A. CONDUCT RESEARCH
B. TARGETED PROGRAMS

PRE-COLLEGE LEVEL EDUCATION PROGRAMS

A. PROGRAMS TO IMPROVE QUALITY OF SCIENCE EDUCATION:

The National Science Resources Center (NSRC) is a project jointly sponsored by the National Academy of Sciences and the Smithsonian Institution. The DoD has provided approximately one-third of the funding for a study to examine factors which could improve the quality of science teaching at the elementary school level. Activities of the NSRC during the first three years of a five-year program have been to identify school systems which provide exemplary science programs; collect science resource materials; disseminate information on science resource materials through a network established by NSRC; develop instructional materials for three critical science concepts; field test these materials; and conduct training workshops for elementary science teachers. The field testing was conducted at 21 elementary schools in 13 school systems including DoD Dependents Schools in the Philippines and several schools with large black or hispanic student populations. A workshop conducted in 1987 involved participants representing 13 school systems with a combined enrollment of over 500,000 students. Negotiations are currently in progress to make the materials available through a commercial vendor. The results of the study will be widely disseminated to the DODDS system. The major thrust of the program is to improve the quality of science teaching methods and to stimulate an interest in science at an earlier age. The DoD portion of the program was conducted under the authority of the Secretary of Defense to undertake studies on subjects of interest to the Department.

Another program which addresses quality of S&T education is the ARMY HIGH SCHOOL SCIENCE AND MATHEMATICS FACULTY program, administered by the Army Research Office, which provides six to ten weeks of experience in an Army laboratory for high school faculty members. The experience is intended to provide an appreciation for the professional challenges undertaken by scientists and engineers; an exposure to current state-of-the-art research topics; and hands-on experience with modern research instruments. The program is conducted at 30 Army laboratories at various locations around the country during the summer months. Pay of $450 per week is provided. The program is considered to be successful and (barring major Army budget cuts) will continue at the current level.

B. PROGRAMS TO STIMULATE INTEREST IN SCIENCE AND TECHNOLOGY CAREERS:

Programs in this category are intended to capture the interest of students at an earlier age through awareness of science

activities and to provide students with information on opportunities in science and technology careers. Many programs involve brief exposure of students to science activities through tours of DoD laboratories and centers, lectures by DoD scientists and engineers in the school, or use of DoD scientists as judges in science fairsa, etc. Expenditures of funds for these activities are small and mostly consist of the duty hours expended by individuial employees in these activities. Because of the diffuse nature of these activities, data are generally not available on the numbers of participants or the funds expended in these programs.

The Army and Navy, through the Army Research Office and the Office of Naval Research respectively, have made a concerted effort to stimulate and encourage the future technical development of our nation's youth through involvement in the national science fair program, which typically attracts about 100,000 students annually. The Army contribution to the program, the ARMY SCIENCE FAIR program, involves the award of 1st and 2nd place prizes at each of the 350 state and regional science fairs, and awards in each of 13 categories at the national fair. Trips to international fairs in London and Japan are provided to winners in the U.S. national fair. Total awards amount to $50,000. The NAVY SCIENCE AWARDS program follows a similar format with awards totalling $200,000.

An example of a more structured approach to these activities is the ADOPT-A-SCHOOL program carried out by many DoD facilities. An example of this type of program is one initiated in school year 1989-90 by the Defense Nuclear Agency, in which the George Washington Junior High School was "adopted" by agreement with the Alexandria, VA public school system. Thirty-six DNA employees have volunteered to support the school by tutoring students; providing assistance on math/science research projects; judging science fairs; participating in career day presentations; lecturing on math/science/technology subjects; hosting Honors Teas for students and parents; providing instruction to students and staff on the use of computers in science and math; and serving as mentors for the students. Adopt-A-School programs were established in 1983-84 in many locations following a memorandum from President Reagan to the Federal departments and agencies. Vigorous Navy programs were established in the San Diego and Great Lakes areas in 1984. Statutory authority for the program was provided by Section 9111 of Public Law 101-165, the Department of Defense Appropriations Act for Fiscal Year 1990, which directed the Secretary of Defense to review partnerships with schools programs; designate a senior official in each of the Services to be responsible for developing these programs; and encourage the participation of all DoD personnel in such programs where they serve as unpaid volunteers under the direction of professional staff in the schools. Supporting testimony for the Bill, published in the Record accompanying the Appropriations Act, noted that there were 275 Partnerships-with-Schools programs nation-wide, with 75 in the

Florida area as a result of Navy initiatives there. However, none of these programs was reported in the survey.

A more comprehensive stimulation program is the JUNIOR SCIENCE AND HUMANITIES SYMPOSIUM, the first and largest pre-college program sponsored by DoD. The program, initiated in 1957 and administered by the Army Research Office, consists of two to three-day regional meetings, which include presentations of papers on research performed by the students; tours of research facilities; a keynote talk by a prominent scientist; discussions on current issues in science; career guidance; and discussions on the relationship of science and the humanities. The program reaches approximately 10,000 students and 250 teachers annually. Ninety-eight percent of the participants go on to attend college but no data are available on the number that pursue careers in science or technology.

The TEXAS PRE-FRESHMAN ENGINEERING program (TEXPREP) is similar in scope but was established by a consortium of state and local governments, colleges and universities, federal agencies, and private industry in the state of Texas. The program involves academic instruction and tours and presentations on science and engineering subjects to students in grades 6-11 who have high potential for science or engineering careers. Defense Mapping Agency supports the program by providing salary support for 12 college student Aids to the program who are employed at DMA under the Summer Aid Program (Federal Personnel Manual (FPM) Ch. 332, Appendix J) and by hosting tours of their facility. The program has a high percentage of women and minority participants (91 percent in 1989) and has had an outstanding success rate in encouraging students to attend college (90 percent), and of those attending college to pursue careers in science and engineering (60 percent).

C. PROGRAMS TARGETED TO STIMULATE INTEREST IN SCIENCE AND TECHNOLOGY CAREERS AMONG MINORITIES, WOMEN AND HANDICAPPED PERSONS:

Activities pursued in this category are very similar to those described above but are targeted for women, minorities, and handicapped persons, groups which are traditionally less likely to pursue careers in science or engineering. The DoD also has broader authority to conduct programs in this area under the direction of Executive Orders and the EEO programs implemented to carry out these orders.

The UNINITIATED INTRODUCTION TO ENGINEERING (UNITE) program, administered by the Army Research Office, provides a four-week intensive experience, primarily for minorities (98 percent), but not exclusive of other disadvantaged youths. The programs are conducted at eight universities distributed across the U.S. and consist of academic instruction on trigonometry, pre-calculus,

computer science, physics, chemistry, and communication skills. Tracking from this and similar programs indicates that approximately 80 percent of minority students who enter engineering participated in some type of summer enrichment program.

Other examples of successful pre-college programs conducted at the local level include the MINORITIES IN ENGINEERING and HANDICAP OUTREACH programs conducted by the Naval Air Development Center in Warminster, PA. The MINORITIES IN ENGINEERING program consists of two-hour sessions held every two to three weeks during the school year at NADC. The sessions include, introduction to digital electronics; computer programming; career workshops college information; a tour of the center; and a student project. Evening introduction and graduation sessions are held with the parents. Students are drawn from four local high schools upon recommendation of science teachers and interviews. The program is targeted for minorities and conducted by the EEO office but others are not excluded. A tracking program has been initiated but the results are not yet available. The HANDICAP OUTREACH program targets junior and senior high students with a disability and involves tours of NADC and establishment of a mentor relationship with NADC employees with a similar handicap. The TECHNICAL MENTOR program at Naval Weapons Center is intended to provide support to women, minorities, and economically disadvantaged youths who are under-represented in science and engineering. The program starts with high school juniors who perform educationally related tasks in an unpaid status under the student volunteer program. During their senior year these students are hired as student aides under the Stay-in-School program (Schedule A 213.3102(w)) for a period of one year. The appointments may be renewed if eligibility requirements are still met.

D. PROGRAMS TO STIMULATE INTEREST IN SCIENCE AND TECHNOLOGY CAREERS BY PROVIDING A WORK EXPERIENCE IN DOD LABORATORIES:

The thrust of these programs is to stimulate interest in science and engineering careers through a hands-on work experience in a DoD laboratory and a mentor relationship with an active scientist. A DoD Instruction was issued in 1981 to establish the DOD SCIENCE AND ENGINEERING APPRENTICESHIP PROGRAM FOR HIGH SCHOOL STUDENTS. Students work on research projects in DoD Laboratories or with principal investigators at universities who have DoD research contracts or grants. Since 1981, when the program was concentrated primarily in the Army and Navy laboratories in the Washington, D.C. area, this initiative has grown to include participation by all three Services. A variety of authorities may be used to implement the program with the most flexible being Schedule A, 213.3102(q). The Office of Naval Research administers the local program for the Washington, D.C. area on behalf of the Army and Navy laboratories in the area, via a contract with George Washington University. The contractor provides for recruiting,

screening and matching student apprentices with laboratory mentors. The program placed 667 participants in 24 laboratories and organizations in the Washington-Annapolis area in 1989 for a period of ten weeks during the summer. Teachers can also participate and earn credit with additional weekend lectures prior to the start of the student program. Students and teachers work on real research projects in DoD labs under the tutelage of a DoD civilian scientist. The students and teachers prepare reports on their projects and present the results in a staff seminar. Teachers monitor and coordinate the activities of the students. The Air Force has a similar program for students in the Dayton, OH area which involves an eight-week experience and is called the HIGH SCHOOL APPRENTICESHIP program. Again a contractor is used to help recruit and place apprentices in the Air Force laboratories. There were 103 participants in 1989.

The HIGH SCHOOL APPRENTICESHIP and RESEARCH AND ENGINEERING APPRENTICESHIP (REAP) programs, sponsored respectively by the Office of Naval Research and the Army Research Office, also derive their authority from the DoD Instruction, but rather than placing students in DoD laboratories, these initiatives provide research experiences for high potential high school students in an academic environment. Students are placed with Principal Investigators on DoD research grants and are paid minimum wages during the work period. The Navy had 80 apprentices and the Army had 110 at 56 institutions during 1989 programs. Surveys indicated 85 percent of the REAP students attended college.

The NRL GIFTED AND TALENTED program and the Naval Coastal Systems Center GOULD SCIENCE AWARD provide work experiences for the students over an extended period of time. The Gifted and Talented program of the Fairfax County Public Schools allows high achievement students in their junior and senior years to work in local industry and government facilities. The students work up to 20 hours per week during school and holiday periods at NRL under Schedule A, 213.3102(q) and DODI 3218.1. The Gould Science Award is given to the top science students in three of the NCSC area local high schools and the students are offered a summer appointment following their senior year.

Students with less experience, such as junior high school students, may be allowed use of government facilities for STUDENT VOLUNTEER SERVICES under Chapter 308, Federal Personnel Manual. OPM has relaxed the age limit for the student volunteers to allow 14 and 15 year olds to participate, as long as there is no conflict with state and local child labor laws.

UNDERGRADUATE LEVEL PROGRAMS

The main purposes of DoD support for undergraduate science and education programs are to provide a supply of college graduates trained in science and engineering for the Services; to provide work experiences for students that may assist in recruiting; and to provide job related training for full-time employees. The largest undergraduate program is the ROTC program which in recent years has selectively sought science and engineering majors. Several of the older summer programs such as STAY-IN-SCHOOL, FEDERAL JUNIOR FELLOW, and SUMMER AID were conceived as means to supplement the incomes of students from low income families who would otherwise not be able to attend college. The COOPERATIVE EDUCATION (CO-OP) program is designed to provide on-the-job work experience and a supplement to income interspersed with full-time academic periods. The newest undergraduate programs are targeted on increasing the number of minority students pursuing careers in science and technology.

A. PROGRAMS TO PROVIDE SCHOLARSHIP SUPPORT:

All three Services operate RESERVE OFFICER TRAINING CORPS (ROTC) programs at cooperating universities nation-wide under the authority of 10 U.S.C. 2101-2107. There are a total of 850 universities with an ROTC affiliation and 87,000 students participating in ROTC training, most in non-scholarship status. The ROTC program was initiated in 1916 under the Morrell Act, but since 1964 the program has been refocused to emphasize scholarship support and active recruitment of science and engineering majors. The Air Force program in particular recruits 70-80 percent science and engineering majors while the Army program does not emphasize preference. The Army program had 10,350 participants on scholarship in 1989, the Navy had 6,589, and the Air Force had 4,800 for a total of 21,739 on scholarships. Approximately 13,000 (60 percent) of this total are majoring in science, math and engineering fields. Scholarship support of tuition, books, fees and $100 per month are paid during the school year and summer training and cruises bring the total support to approximately $8000 per year. Total support for the S&E scholarships amounted to $105 million in 1989. The graduates are obligated to four years active duty military service but may be commissioned in the reserves depending on force requirements. Reductions-in-force anticipated in the next several years will reduce the total number of officers commissioned through ROTC programs, but the number of scholarships offered is anticipated to remain fairly constant.

The Army has developed an alternative ROTC program called the SCIENCE AND ENGINEERING ROTC CO-OP program, separate from the basic program described above, to recruit scientists and engineers.

Students must be enrolled at one of 145 participating universities that offer a science and engineering curriculum, an Army ROTC program, and have a cooperative education (Co-op) program. The students are eligible for up to $5000 per year for tuition, fees, and room and board. Participants are also offered co-op jobs at Army labs with additional pay for the work period. Upon graduation, the students are commissioned in the Army Reserves and are obligated to work at an Army lab until a service commitment is met. The program was conducted on an experimental basis for five years and has recently been adopted permanently and transferred to the Army Personnel Command for administration. Initial efforts to recruit for active duty service were not as well received as the Reserve status. The program currently has 216 participants.

B. PROGRAMS TO PROVIDE RESEARCH EXPERIENCE:

COOPERATIVE EDUCATION (CO-OP) programs, to provide alternate periods of work experience and academic education, are available at many universities and colleges. The program is usually open to sophomore or junior level students meeting certain academic standards. The program allows more informed choices of career specialties for students as well as providing supplements to their income. The program has proven to be an effective recruitment method for undergraduate personnel and provides an opportunity to evaluate a potential employee's abilities before hiring. Chapter 308, Federal Personnel Manual, "Youth and Student Employment Programs," describes co-op programs for the undergraduate, associate degree, and graduate level. Students in the undergraduate program are appointed under Schedule B, 213.3202(a) which permits up to 1,040 hours of work per year at a GS-2 or 3 level, consistent with their qualifications. Students may be converted to career conditional appointments upon graduation. Components reporting undergraduate co-op programs included Defense Mapping Agency; Naval Sea Systems Command HQ; Naval Facilities Command; and Naval Research Laboratory. Air Force laboratories, National Security Agency, Naval Oceanographic Research Laboratory, and Naval Air Development Center reported the statistics for the graduate and undergraduate co-op programs together.

The STAY-IN-SCHOOL program is intended to provide supplemental income for students who would have difficulty meeting the financial burdens of a college education. The need requirements for admission to the program are established annually by OPM. The program permits high school and undergraduate college students to work up to 20 hours per week during the school year and full-time during summer and holiday vacation periods, not to exceed 1,040 hours per year. Appointments are under Schedule A, Section 213.3102(w) for a period of one year but may be extended for additional periods not to exceed one year. Organizations reporting participation in this program included Defense Mapping Agency and Naval Coastal Systems Center. The FEDERAL JUNIOR FELLOW program

is somewhat similar to the Stay-in-School program but also has a merit requirement for students to be in the top ten percent of their classes in addition to having financial need. Students are appointed upon graduation from high school and work the summer after graduation and succeeding summers and vacation periods while in college. Students are eligible for non-competitive appointment to career conditional positions upon receipt of their degrees. The program is authorized under Chapter 308, Federal Personnel Manual. Organizations reporting Federal Junior Fellow programs include Defense Mapping Agency; Naval Research Laboratory; Naval Air Development Center; and the Naval Coastal Systems Center.

The Naval Research Laboratory makes use of the provisions of Excepted Service Schedule A, 213.3102(q) to hire approximately 80 college or high school students as research aids during summer and holiday breaks or intermittently during the year. The total hours cannot exceed 1,040 per year, hence the name of the program, 1040 HOUR APPOINTMENT.

The SUMMER AID program provides for summer employment of needy youths to provide job experience and allows reappointment of those with satisfactory performance. Applicants must be referred by a state employment agency and are ranked in order of need. The program is described under Chapter 331 appendix J-6 with hiring under Schedule A, 213.3102(v). Defense Mapping Agency and Naval Electronic Systems Engineering Activity use the program.

The SUMMER HIRE program of Naval Research Laboratory and S&E SUMMER EMPLOYMENT program of Naval Air Development Center are merit programs conducted under authority of OPM Regulation 316.402(a). These programs provide summer work experience for students in disciplines of interest to the agency and are highly competitive. The National Security Agency conducts a similar SUMMER PROGRAM, but is given authority for excepted service under Public Law 86-36.

C. PROGRAMS TARGETED TO INCREASE PARTICIPATION OF MINORITIES IN SCIENCE AND TECHNOLOGY CAREERS:

Executive Order 12320 in 1980 and Executive Order 12677 of April 28, 1989, provided for the establishment of programs to strengthen the Historically Black Colleges and Universities (HBCUs) by providing assistance and advice to faculty, and training opportunities for their students. This has resulted in the development of a number of programs such as the HBCU initiative and ADOPT-A-COLLEGE to respond to the Executive Order. Most use the authorities for student employment and OPM excepted service schedules such as those described above, but are specifically targeted on the HBCUs. The Office of Naval Research has developed a comprehensive program to address both the availability of students and faculty research. The Naval Oceanographic Research Center has established an Adopt-a-College program with Jackson

State University and provides summer job opportunities for undergraduate and graduate students and faculty members in science and engineering disciplines. The Naval Air Development Center has targeted about a dozen schools with black and hispanic populations which conduct engineering programs and various NADC departments have adopted each of the schools to establish communication on NADC career opportunities. Students participate in two-day visits to NADC, co-op programs and faculty work in summer research programs. Defense Mapping Agency is just developing a program which will include the usual summer programs, co-ops, and faculty exchange, as well as providing excess equipment to HBCUs and providing opportunities to bid on research contracts.

The ONR HBCU program currently funds $3.9 million per year in research and scholarship support to HBCUs. Six additional grants for a total of $14 million over a five-year period were recently announced. The grants to the schools will fund a spectrum of programs including direct scholarship/research assistantship support to more than 100 undergraduate students; faculty research grants; student summer research experiences; visiting scholars; and improved laboratory training. Each of the schools is expected to complement the ONR support with existing programs to stimulate interest and improve teaching of science and engineering in grades K through 12. The ONR program will attempt to reduce attrition at the undergraduate and graduate levels.

The National Security Agency conducts a unique UNDERGRADUATE TRAINING program for minority students to provide educational and conditional employment opportunities. The program requires an SAT score of 1100, a GPA of 3.0 and an interest in science and math fields of interest to NSA. The program pays tuition and incurs an obligation of one and one-half years of service for each year in the program. The program currently has 37 participants and an expansion to 50 is planned for 1990. The program authority is the National Security Act of 1959 as amended by Section 505 of Public Law 99-569.

D. PROGRAMS TO PROVIDE JOB RELATED TRAINING FOR EMPLOYEES:

The DoD makes a significant contribution to education in science and technology fields through the training and education programs provided for its own employees who comprise 3 percent of the national pool of scientists and engineers. The basic authority for training programs is contained in 5 USC, Ch. 41 and E.O. 11348 of April 20, 1967. The provisions of these authorities are described in Chapter 410, Federal Personnel Manual. Training may be full-time, part-time, on or off-duty, day or evening. It may be given by the agency itself; an educational institution; another Federal agency; a professional association; or by a manufacturer. Agencies may pay for all or part of the expenses of authorized training. The purpose of training is to provide improved public

service, cost savings, and the development and retention of a cadre of skilled and efficient government employees who are abreast of current scientific, technical, professional and managerial developments. The training must be in fields which are or will be directly related to the performance of official duties for the government. Training covers many activities such as attendance at conferences, short courses, etc. For the purposes of this report, only training activities which provide formal educational course work in science, math, or engineering disciplines at an accredited academic institution (or Agency programs of equivalent stature) will be considered as S&T education programs. Most training programs apply equally to undergraduate and graduate course work and many organizations do not differentiate between them. As a result, it is difficult to separate the participation and expenditure levels between undergraduate and graduate programs.

The Naval Air Development Center offers a PART-TIME UNDERGRADUATE STUDY AWARD program for non-science and engineering employees who wish to pursue a scientific or technical degree. The employee must have already completed one full academic year in the subject field and have career status (three years government service) with one year employment at NADC. Participants may receive up to 20 hours education per week at a local college or university with full pay, tuition and academic fees. Appointment to the program is for one year, renewable until the B.Sc. degree is granted, if progress is satisfactory. An obligation of three years service for each year of training is incurred. The UNDERGRADUATE ACADEMIC program of the Naval Ocean Systems Center offers a very similar program except it is limited to nine credit hours per semester and applies only to upper division courses. The National Security Agency offers an ADVANCED STUDIES program on the 20 hours study-20 hours work format.

The National Security Agency offers an AFTER-HOURS COLLEGE program for up to eight credit hours per semester at a local college in job related courses for both undergraduate and graduate level courses. The Defense Nuclear Agency also reports a similar program for off-site educational opportunities for employees.

The National Security Agency is also authorized by DoD Directive 5100.47 to operate the NATIONAL CRYPTOLOGIC SCHOOL to provide specialized education and training for employees in computer science, electronic engineering, cryptology and related fields. The courses are both undergraduate and graduate level, and are taught during duty hours.

Long-term/full-time training programs which permit residence at a college or university campus are offered by most components although primarily at the graduate level. The Defense Mapping Agency offers their LONG-TERM - FULL-TIME TRAINING program to full-time permanent employees with two years continuous service, a TOP SECRET clearance, high potential, and relevant academic background.

The employees must pursue training in cartography or related disciplines; be willing to relocate; and incur a three-year service obligation for each year of training. In 1989, 4 of 35 participants were enrolled in undergraduate education programs. The Naval Weapons Center offers a LONG-TERM TRAINING program similar to the one above but concentrated in science and engineering fields of interest to NWC, without the requirement for the TOP SECRET clearance and willingness to move. The National Security Agency offers an external training program called the DIRECTED FELLOWSHIP/SCHOLARSHIP program which is similar to the above programs but pays travel expenses and 50 percent per diem after the first 30 days on campus.

Another special type of training program is the Career Intern program which involves rotation of job assignments for entry level personnel intended for administrative, professional and technological fields particularly for positions with management and executive responsibilities. This may also include some educational training as part of the program. Career Intern programs are described in Chapter 361, Federal Personnel Manual and include entry at GS-5,7 and in some cases 9 level and are intended to bring new entrants to the full performance level over a period of several years. Recruiting for positions in the Intern program may be done directly out of college. Examples of this type of program include, the Naval Air Systems Command ENGINEER AND SCIENTIST DEVELOPMENT program; the Naval Facilities Engineering Command PROFESSIONAL DEVELOPMENT CENTER program; the Space and Naval Warfare Systems Command ENGINEER AND ACQUISITION MANAGEMENT program; the Naval Coastal Systems Center NEW PROFESSIONAL DEVELOPMENT program; the Naval Electronic Systems Center ACCELERATED PROMOTION program; and a somewhat less regimented program administered by the Air Force Civilian Personnel Management Center called CIVILIAN SCIENTISTS AND ENGINEERS CAREER program. The costs listed in Appendix B for the career intern programs identified above reflect the complete cost of the programs rather than that part associated strictly with education.

Finally, the National Security Agency offers two programs intended to provide staffing for skilled positions below the B.Sc. level where personnel are in short supply. The GROW YOUR OWN program addresses the need for technician level personnel for collection operations, signals conversion, telecommunications, traffic analysis and computer operations technicians. High school graduates and agency employees are recruited for this program which provides a combination of formal and on-the-job training to bring the participants to the journeyman level of competency. Graduates of the program are obligated to remain in the field for which trained for two years. The COMPUTER OPERATIONS ASSOCIATES program is targeted for community college students in computer science, data processing or computer operations programs. The students are partially supported for a continued educational and on-the-job

training program that leads to an Associate degree and qualification for a GS-5 or 7 position.

GRADUATE LEVEL PROGRAMS

Graduate level education is the largest area of support by the DoD and is focused on the physical sciences, engineering, and mathematics. These skills are crucial to the accomplishment of the Department's mission, however, there is a shortage of these skills, particularly among U.S. citizens. The graduate level programs include direct support of educational training through fellowships; indirect support through research grants to universities which provide for research assistantships for graduate students; and training programs for DoD employees.

A. TO PROVIDE EDUCATIONAL SUPPORT THROUGH FELLOWSHIPS:

The DoD provided fellowship support to approximately 540 students in 1989 through programs administered by the Army Research Office (ARO), the Office of Naval Research (ONR), the Air Force Office of Scientific Research (AFOSR), and Defense Advanced Research Projects Agency (DARPA). These programs are all advertised nationally through the distribution of brochures to schools and principal investigators on DoD contracts and grants, through advertising in professional society journals and announcements at professional society meetings. The fellowship programs are authorized as part of the annual appropriation for DoD research programs or, in the case of the National Defense Science and Engineering Graduate Fellowship program, directly in 10 USC 2191.

The AFOSR supports two of the oldest fellowship programs, ADVANCED THERMIONIC RESEARCH INITIATIVE (ATRI) and AIR FORCE RESEARCH IN AERO PROPULSION TECHNOLOGY (AFRAPT), both of which are targeted on critical Air Force needs and are concentrated at a few cooperating schools. The ATRI Fellowship program was initiated in 1977 at Stanford, transferred to University of Utah in 1981, and to UCLA in 1987. It is focused on microwave and millimeter wave thermionic amplifiers and components and requires a B.Sc. in Electrical Engineering and U.S. citizenship as prerequisites. Thesis topics are cleared by an advisory board from UCLA, industry and the Air Force. A stipend of $14,000 per year plus tuition and fees is paid. To date, of the 69 graduates of the program, 56 are working in thermionics related fields. There are 20 students in the current class and graduates are in high demand. The AFRAPT program is a fellowship co-op program involving AFOSR, industry and university cooperation to provide a supply of critically needed engineers in the aeronautical propulsion field. Participants must be employed by Allison, Textron, Garrett, General Electric or Pratt and Whitney, and attend one of the cooperating universities which include MIT, Purdue, Texas A&M, Princeton, and Penn State. The students are typically selected for the program in June, work at

their respective companies over the summer and begin graduate study in the Fall. Thesis work may be done either at the university or at the supporting company. A monthly stipend of $1400 per month plus tuition and fees is paid during academic periods and competitive salaries are paid during periods of work at the company location. The program has had 60 trainees since its inception in 1982 and although there is no obligation to continue employment following graduation, approximately half of the graduates are currently employed in the gas turbine industry. Of the current 35 participants, one-third are pursuing Ph.D. degrees and the balance are in M.Sc. programs. The program is considered to be highly effective. The JOINT SERVICES ELECTRONICS COMMITTEE has recently initiated another fellowship program targeting the electronics area. The program started in 1989 at a level of $90,000 and is intended to increase to $300,000 in 1991.

The LABORATORY GRADUATE FELLOWSHIP PROGRAM (LGFP) is another AFOSR program designed around the fellowship co-op concept. The program is primarily focused on the physical sciences and engineering, but does include life sciences and behavioral sciences opportunities. Each fellow is assigned to an Air Force laboratory researcher, working in the same area of interest as the follow, who serves as the fellow's mentor and advisor. Fellows are encouraged to spend the summer period at their sponsoring laboratory. Fellows receive stipends of $15,000 the first year, $16,000 the second year and $17,000 the third year plus tuition and fees. The university department attended by the fellow receives $2,000 per year. Universal Energy Systems has operated the program under contract to the Air Force. The current contract expires August 31, 1990, and it is anticipated that Southeastern Center for Electrical Engineering Education will continue the program under a new contract. Fellowships are awarded on the basis of merit and are screened by an Air Force advisory committee and the contractor. The program currently has 75 students, and although the program is too new to provide a data base of employment history, there has been only one drop-out from the program to date. It is considered to be very successful in attracting high-potential students to science and engineering disciplines of interest to the Air Force. The Office of Naval Research sponsored ONR GRADUATE FELLOW program is similar in concept and scope to the Air Force program. Targeted fields include the physical sciences; engineering; biological science; oceanography; and cognitive and neural science. Stipends are $15,000 the first year, $16,000 the second year and $17,000 the third year, plus tuition and fees. The students are encouraged to work in Navy laboratories during summer and vacation periods. Approximately 50 awards a year are made on the basis of merit as determined by an advisory panel of technical experts. Approximately 100 Ph.D.s have been earned by participants in the program and an attrition rate of less than 7 percent has been observed. The American Society for Engineering Education is the contractor for the program. Program history, exit surveys from fellows, and evaluations from the selection panels indicate the program is very

successful in attracting high quality students, in retaining them, and in integrating them into the research infrastructure. The Navy plans to continue the program at approximately the present level. The Army SCIENCE AND TECHNOLOGY FELLOWSHIP program, administered by the Army Research Office, was similar to the above Air Force and Navy programs and had 53 and 57 participants respectively, in 1987 and 1988. The program is being phased out in favor of two new fellowship programs (URI and NDSEG) and has only eight fellows left in the program. It will be terminated when they complete their degrees. The Army UNIVERSITY RESEARCH INITIATIVE program has a large fellowship component in the program which in 1989 had a budget of $3 million and supported 149 fellows. The program, administered by the Army Research Office, is targeted on the physical sciences and engineering and is intended to increase the number of students pursuing careers in science and engineering. The program is planned for a future level of about 130 fellows and funding of $2.5 million per year.

The NATIONAL DEFENSE SCIENCE AND ENGINEERING GRADUATE FELLOWSHIP (NDSEG) program is the most recent fellowship program and has specific authorization in 10 U.S.C 2191 as amended in 1989. Fellowships are awarded for study and research leading to doctoral degrees in the fields of mathematics, physical science, biological science, oceanography, and engineering. The program is sponsored by the three Services and DARPA and operated by Battelle under contract. The fellows are provided with stipends of $15,000 per year the first year, $16,000 the second year, and $17,000 the third year as well as full tuition and fees for three years. DoD also provides $2,000 per year support to the fellow's department at the university. Fellows are selected on the basis of merit by panels of experts convened by Battelle in each discipline. Approximately 4,200 applications were received for the first competition, and 126 fellows were selected with support as follows: ONR-39; ARO-31; AFOSR-30; and DARPA-26. The program is planned for support at the level of $10 million in 1989, $10.5 million in 1990 and $11 million in 1991 with selection of approximately 120 fellows per year for the three-year fellowship (forward funded to cover 3 yrs.). The program appears to have been well received and has had high quality applicants.

B. PROGRAMS TO PERFORM RESEARCH:

RESEARCH ASSISTANTSHIPS: The DoD is authorized to contract for research and to provide grants in areas of research which are relevant to the mission of the Department. In 1989 DoD funded approximately $800 million in basic and applied research contracts and grants to universities and colleges (exclusive of R&D centers operated by universities) to conduct research in areas of interest to the DoD. A major subsidiary benefit of this research was the training of graduate students in fields of science and engineering of critical importance to DoD. The most recent National Science Foundation survey of Scientists and Engineers (5), indicated 8,235

full-time graduate students were being supported by research assistantships and other related support in 1987. Assuming a cost of $19,000 per year for graduate assistantships, the level of support for this mechanism would be $156.5 million per year. Research programs of DoD are administered by the Army Research Office, the Office of Naval Research, the Air Force Office of Scientific Research, and the Defense Advanced Research Projects Agency and are coordinated by the Office of the Director for Defense Research and Engineering, Research and Laboratory Management. Individual assistantships are selected by the Principal Investigator and the school, and are not limited to U.S. citizens or nationals. This program was initiated by the Office of Naval Research in 1946 and was subsequently expanded to the other Services and DARPA. It has been responsible for the training of a large number of the scientists and engineers who now work in the physical sciences and engineering. Perhaps more than any other DoD program, it has made a major contribution to the nation's supply of highly trained scientists and engineers.

C. PROGRAMS TO PROVIDE RESEARCH EXPERIENCE:

Many of the programs that provide research experience at the undergraduate level are also conducted at the graduate level. In particular the CO-OP programs and the SUMMER HIRE programs are used extensively at the graduate level. The reports on these programs did not differentiate between undergraduate and graduate levels of support. The Air Force GRADUATE STUDENT RESEARCH program is an example of a specific program of this type that provides for a ten-week research experience for graduate level science and engineering students. The program is closely coordinated with the Summer Faculty Research program so that the faculty members can supervise the research of the students. Provision is also made for Air Force scientists to serve as advisors in case summer faculty participants are not available for a particular research area. The program is administered by Universal Energy Systems under contract to the Air Force.

Congress amended Title 10 USC in 1982 to add section 2360, which allows the Secretary of Defense to procure by CONTRACT the temporary or intermittent SERVICES OF STUDENTS at institutions of higher learning for the purpose of providing technical support at defense research and development centers. These contracts can be made either directly with the students or with a non-profit organization employing the students. The students are covered by workmen's compensation but are not otherwise considered government employees. No organizations reported the use of this statute in the survey, perhaps because it was not considered a science and technology education program. Other sources indicate the Army Medical Research and Development Command employs about 400 students and the Army Corps of Engineers employs about 350 under this provision. The statute accomplishes much the same thing as the

student employment programs described in Chapter 308, Federal Personnel Manual, although with greater flexibility.

D. PROGRAMS TO PROVIDE SCIENCE AND ENGINEERING EDUCATION FOR EMPLOYEE TRAINING:

Training programs for employees are conducted under the same authority and under the same terms as those previously described for the undergraduate level. The programs basically fall into the categories of tuition support for a few courses, part-time work programs, and full-time, long-term programs. Under conventional OPM training rules, the acquisition of a degree as an end objective is not allowed although the incidental earning of a degree as a byproduct of the training is acceptable. This places the DoD at a disadvantage when compared to most industry benefit packages. The Air Force is evaluating two programs in this area which emphasize the need for academic training as part of the preparation for attaining competence in technical and management positions.

Examples of the short-term tuition support programs include AFTER HOURS TUITION SUPPORT at Defense Intelligence Agency; the TUITION ASSISTANCE program of the Defense Mapping Agency; the NAVSEA INSTITUTE at Naval Sea Systems Headquarters (which offers career specific courses in cooperation with Virginia Tech); INSTRUCTIONAL TELEVISION offered by Naval Ocean Systems Center and Naval Research Laboratory; special ON-SITE EDUCATION CENTER CLASSES provided by arrangement with the University of California at Chico State and Irvine to service employees of the Naval Weapons Center through live and televised graduate and undergraduate classes; and a similar arrangement at the Army Corps of Engineers WATERWAYS EXPERIMENT STATION GRADUATE INSTITUTE in cooperation with Louisiana State, Texas A&M, and Mississippi State Universities.

Examples of part-time study programs include the EDISON MEMORIAL TRAINING program at Naval Research Laboratory, which provides for 24 hours of work per week and 16 hours per week of academic study at full salary after one year at NRL. The opportunity is limited to one year in ten (exceptions granted for two/ten). The GRADUATE ACADEMIC program at Naval Ocean Systems Center is similar with a 20 hour academic/20 hour work program at full salary.

Examples of long-term graduate training programs which allow full-time attendance at school at full salary and tuition, usually after three years of service and with a three-year obligation of continued service for each year of education provided include the MISSION RELATED GRADUATE program at the Army Corps of Engineers; the LONG-TERM GRADUATE TRAINING programs at the Naval Sea Systems Headquarters and the Naval Ocean Systems Center; FULL-TIME GRADUATE EDUCATION program at the Naval Air Development Center; FULL-TIME STUDY program at the Defense Intelligence Agency; and ADVANCED

GRADUATE RESEARCH program at the Naval Research Laboratory. The Naval Research Laboratory offers a slight variant to this format in the SELECT GRADUATE STUDENT program which offers one-half salary support for full-time study after only one year of government service. Several organizations offer long-term training opportunities in specific disciplines critical to the organization such as OPERATIONS RESEARCH SYSTEMS ANALYST FELLOW offered by Headquarters of the Department of the Army and OPERATIONS RESEARCH ADVANCED FELLOW offered by the Army Materiel Command; the DCI EXCEPTIONAL ANALYST offered by the Defense Intelligence Agency; and the COASTAL ENGINEERING EDUCATION program, WATER RESOURCES PLANNING ASSOCIATE and WATER RESOURCES AND ENVIRONMENTAL LAW ASSOCIATE, all offered by the Army Corps of Engineers.

The Air Force has two unique programs that couple recruiting with advanced educational programs. The PALACE ACQUIRE program, using OPM direct hire authority, recruits recent college graduates in engineering disciplines into the Career Intern program and offers them the opportunity to pursue advanced job-related studies which may lead to a M.Sc. degree during the trainee period. The program has been in operation since 1986 with about 50 interns per year, and very satisfactory results. The PALACE KNIGHT program is another program developed and administered by the Air Force Civilian Personnel center which enables personnel to pursue advanced studies in their career field at both the M.Sc. and Ph.D. level. New recruits are hired at the GS-7 level and report directly to their universities as their first duty stations. They usually receive a Masters degree as a by-product of the studies during the the first one to two years, then are assigned to a lab/work position for three years. With satisfactory ratings in their work assignments, the Palace Knight trainees can then return to school to continue their studies, which usually lead to a Ph.D. degree as a by-product of the advanced study. Full salary, tuition, and relocation expenses to the duty station are paid. A continued service agreement of three years for each year of training must be signed prior to employment. The program is scheduled to start in January of 1990 with approximately 100 participants projected per year.

POST-DOCTORAL AND FACULTY EDUCATION PROGRAMS

Post-doctoral and faculty education programs are primarily in the category of providing exposure to state-of-the-art science and technology for new Ph.D.s, for faculty enrichment, or for enrichment of faculty at minority institutions. Since the programs employ trained scientists and engineers, they are classified as programs where research is conducted. They also serve, however, to introduce faculty to research areas of interest to DoD and, in the case of the post-doctoral fellow programs, are one of the most effective recruiting programs available to the laboratories.

A. PROGRAMS WHICH PERFORM RESEARCH:

The NATIONAL RESEARCH COUNCIL RESEARCH ASSOCIATESHIP program is one of the oldest education programs supported by DoD, dating back to 1957. The program provided placement for 239 post-doctoral fellows in 17 DoD laboratories and centers during 1989, including all three Services and several agencies. Applicants must be within five years of earning their Ph.D. degrees, and must submit proposals for independent research in their areas of interest. The proposals are screened for relevance by the host laboratory and evaluated and ranked by a panel of experts appointed by the National Academy of Sciences. Fellows selected are given appointments at a DoD laboratory of their choice for a period of one year, with an option of renewal for a second year. An active research scientist at the laboratory is assigned as an advisor. Stipends of $32,000 to $34,000 per year plus certain travel allowances and conference fees were paid in 1989. Stipends for 1990 increased to $34,000 per year with slightly higher rates available for engineers. The program is operated for the Department of Defense by the National Research Council. Authority to place NRC Fellows in excepted service is provided in Schedule A, 213.3102(aa). Most associateships are limited to U.S. citizens, but the Air Force accepts foreign nationals in their program. The NRC post-doc program is highly regarded and has provided many outstanding scientists and engineers for the DoD laboratories and centers.

The Office of Naval Technology supports the ONT POST-DOCTORAL FELLOWSHIP program for selected fields of science and engineering of interest to the Navy. The format is similar to the NRC program, but is administered by the American Society for Engineering Education and provides a slightly more generous stipend. The program had 77 participants in 1989 who were placed at participating Navy labs.

SUMMER FACULTY RESEARCH programs are sponsored by all three Services to provide research experiences in DoD laboratories during the summer months. The applicants must be faculty members at accredited colleges or universities, U.S. citizens and preferably hold or be eligible for a SECRET security clearance. The programs typically run ten weeks and pay stipends of $900 to $1500 per week, depending on faculty position, plus travel expenses and a modest relocation expense. Research is performed on a project of mutual interest to the faculty member and the host laboratory. Authority for the programs is covered under Schedule A, 213.3102(o). The Air Force Office of Scientific Research administers the Air Force program through a contract with Universal Energy Systems. There were 150 participants in 1989. The Office of Naval Research administers the Navy program through a contract with the American Society of Engineering Education; 207 faculty were placed at 19 participating Navy labs in 1989. The Army Research Office sponsors a similar program with Battelle as contractor which had 107 appointments at Army labs in 1989. The LABORATORY CO-OP RESEARCH program started by the Army Research Office in 1971 was the forerunner of the Summer Faculty programs. It involved three to six-month sabbaticals at Army labs with full university salary and travel expenses. It is still available but appears to be less popular than the shorter summer faculty program.

The Air Force Summer Faculty program is coupled to a companion program, called the RESEARCH INITIATION program (not to be confused with the University Research Initiative Research Initiation program that uses the same name), which provides grants of $20,000 per year for research projects that evolve from the Summer Faculty program. The projects are carried out at the faculty member's institution. Proposals are submitted after the summer faculty experience and are evaluated for relevance and merit by Air Force laboratory personnel and the contractor, Universal Energy Systems. This program awards 75 grants per year for a total of $1.7 million and is useful for stimulating interest in research areas critical to the Air Force mission and in assisting new faculty members and faculty from HBCUs/MIs to gain experience in these areas.

The Air Force also has a special faculty program for long-term exchanges under the authority of the Intergovernmental Personnel Act of 1970 as amended (Public Law 91-648). The UNIVERSITY RESIDENT RESEARCH program provides for the faculty member to spend one to two years at an Air Force laboratory or AFOSR performing research or administration in an area of mutual interest. The applicant must be a full-time faculty member in a science or engineering field, a U.S. citizen, and hold or be eligible for a SECRET clearance. The university must agree to continue employment of the faculty member upon completion of the sabbatical. Salary is shared by the university and the Air Force, and travel and relocation expenses are paid by the Air Force.

The Office of Naval Research YOUNG INVESTIGATOR program is not strictly an education program but is an innovative program designed to assist new faculty members within five years of their Ph.D. in obtaining their first DoD grants. This program is intended to attract capable new faculty members who are outstanding researchers to areas of research relevant to DoD. In 1989, 44 Grants totaling $2.5 million were awarded.

B. PROGRAMS TARGETED TO INCREASE THE PARTICIPATION OF WOMEN AND MINORITIES:

The WOMEN SCIENCE SCHOLARS program, developed by Office of Naval Research, is intended to provide post-doctoral experience for Ph.D. graduate women who are at a point in their careers where this experience can make a critical difference. It is based at Bunting Institute of Radcliffe College with collaboration at other New England schools. The women are paid a stipend of $25,000 per year for a period of a year. The program is rated highly by the participants and credited with substantially aiding their careers and attracting them to research areas of interest to DoD.

The SUMMER COLLEGE OUTREACH, RECRUITMENT, AND EMPLOYMENT (SCORE) program of the National Security Agency is an affirmative action initiative in support of HBCUs and other minority institutions (MIs). Faculty members of these institutions in engineering, computer science and mathematics fields work at the National Security Agency during the summer months and are introduced to research fields of interest to the agency. The summer experience helps them to keep abreast of current developments in their fields and makes them aware of educational requirements for careers at NSA which should be incorporated in their curricula. It also provides contacts for later NSA recruiting at these institutions.

SUMMARY

Table II provides a summary of participants and funding level in thousands of dollars by education level and by purpose of the program for responses received in the survey. It should be noted that the largest programs in terms of funding are the research assistantships and ROTC scholarship programs with $156.5 and $106 million, respectively. Targeted programs totaled $7 million. Employee training, for those programs reported, amounted to $18 million. This is certainly an underestimate since many laboratories and centers were not reported in the survey.

Some perspective on the education investment at a research laboratory can be gained from Table III which provides a break-down on programs supported at the Naval Research Laboratory, Washington, D.C. In 1988, NRL had 3,576 employees with 497 B.Sc., 323 M.Sc., and 729 Ph.D.s. This table provides a comparison of the magnitude

of various programs and a basis for estimating an approximate support level for various programs such as Co-op, NRC Post-Doc, SEAP, Summer Faculty, etc.

Tables IV and V provide summaries of the participation and funding level for fiscal year 1989 for various types of program supported by the research program and personnel offices. Table IV is based on the data in Appendix B and is relatively complete. Table V is based on the data in Appendices B and C and contains estimates of cost where actual figures were not provided. It represents a lower limit for the various programs listed.

TABLE II

SUMMARY OF SCIENCE AND ENGINEERING EDUCATION PROGRAM PARTICIPATION AND FUNDING - FY 1989

	PARTICIPANTS	FUNDING ($K)
PRE-COLLEGE LEVEL		
IMPROVE QUALITY	5128	793
STIMULATE CAREER INTEREST	12,247	1,137
PROVIDE EXPERIENCE	968	1768
TARGETED	735	108
TOTAL	19,078	3,806
UNDERGRADUATE LEVEL		
ROTC SCHOLARSHIP	13,147	106,331
PROVIDE EXPERIENCE	376	1,516
TARGETED	228	7,088
EMPLOYEE TRAINING	527	7,792
TOTAL	14,278	122,727
BOTH UNDERGRADUATE & GRADUATE LEVEL		
PROVIDE EXPERIENCE	758	2614
TARGETED	3	40
EMPLOYEE TRAINING	20,251	5,457
TOTAL	21,032	8,111
GRADUATE LEVEL		
FELLOWSHIPS	541	20,393
RESEARCH ASSISTANTSHIPS	8,337	157,310
EMPLOYEE TRAINING	1189	6,479
TOTAL	10,067	184,182
POST-DOCTORAL/FACULTY LEVEL		
RESEARCH APPOINTMENTS	933	21,320
TARGETED	13	189
TOTAL	946	21,509
GRAND TOTAL	65,376	340,335

TABLE III

EDUCATIONAL PROGRAMS AT THE NAVAL RESEARCH LABORATORY
FY 1987, 1988, 1989

PROGRAMS	PARTICIPANTS			FUNDING ($K)		
	87	88	89	87	88	89
Student Volunteer	1	2	4	0	0	0
Summer Hire	84	58	55	284	205	196
SEAP	79	98	97	91	113	112
Gifted & Talented	2	3	1	5	8	3
1040 Hr. Appt.	85	78	81	674	354	373
Federal Jr. Fellow	14	11	4	48	44	18
Co-op	143	129	119	835	807	700
ONR Grad Fellow (summer)			6			32
ONT Post-Doc.	30	35	40	975	1138	1440
NRC Post-Doc.	60	60	60	1629	1920	1920
Summer Faculty			49			500
Edison Mem. Grad. Training	15	15	8	203	213	266
Select Grad. Training	2	1	3	45	36	85
Adv. Grad. Training	6	3	4	448	191	315
Technical Training (Total no. courses)	1763	1340	1539	530	474	619
Partners in Education, M. V. Leckie Elementary School Washington, D.C.				0	0	0
Totals				5767	5503	6579

TABLE IV

SCIENCE AND ENGINEERING EDUCATION PROGRAMS SUPPORTED BY RESEARCH OFFICES (ONR, AFOSR, ARO; R&AT(RLM) COORD.) - FY 1989

	SERVICES	PARTICIPANTS	SUPPORT ($K)
1. RESEARCH ASSISTANTSHIPS	All	8235	$156,500
2. FELLOWSHIPS			
ONR FELLOWS	N	139	4,100
URI FELLOWS	A	158	3,163
LAB GRAD FELLOW	AF	50	1,661
AFRAPT FELLOW	AF	45	908
ATRI FELLOW	AF	20	465
JT. SERV. ELECT. FEL.	ALL	3	90
NDSEG FELLOW	ALL	126	10,006
TOTAL		541	20,393
3. POST-DOCS			
NRC	ALL	239	7,624
ONT	N	77	2,185
UNIV. RESIDENT RES.	AF	24	1,942
TOTAL		340	11,751
4. FACULTY			
SUMMER FACULTY	ALL	474	5,339
YOUNG INVESTIGATOR	N	44	2,530
RESEARCH INITIATION	AF	75	1,700
TOTAL		593	9,569
5. HBCU/MI			
HBCU/MI*	N	200	6,500
UNITE	A	686	105
WOMEN SCHOLARS	N	6	174
TOTAL		892	6,779
6. PRE-COLLEGE			
H.S. APPRENTICE	ALL	960	1,765
H.S. S&M FACULTY	A	128	543
JR SCI&HUM SYMPOSIUM	A	10000	850
SCIENCE FAIR AWARDS	A&N	1115	250
NATL SCI RES CNTR*	DDR&E	5000	300
TOTAL		17203	3,708
GRAND TOTALS		27804	208,700

* These broad programs affect entire schools to some degree, estimates of participants are long term involvement.

TABLE V

EDUCATION PROGRAMS SUPPORTED BY PERSONNEL AND EEO OFFICES
FISCAL YEAR 1989

PROGRAM	PARTICIPANTS	($K)
Adopt-A-School	275	0
Summer Aid/Stay-in-School	1563	5470
Junior Fellow	329	1316
Summer Programs	1541	5393
1040 Hr. appointment	81	373
Co-op	2260	15830
Targeted	105	501
Career Intern	2958	110646
Training	19700	49920
TOTALS APPENDIX B AND C *	28812	189449

*Costs are best estimate where not given in Appendices

SECTION III: PROGRAM EVALUATIONS AND OBSERVATIONS

Several in-depth studies of science and engineering personnel needs and science and engineering education programs in the DoD are currently in progress. One study is evaluating the current programs and will recommend a course of action for the near future. Comments were received on the effectiveness of the various programs and a few of these observations will be included. A second study will examine future supply and demand for scientists and engineers in DoD. A third study will evaluate current education programs to identify the elements for successful programs and recommend directions to meet the challenges of the year 2000. The second and third studies are two-year studies jointly funded by the Deputy Director for Research and Engineering (Research and Advanced Technology) and the Assistant Secretary of Defense for Force Management and Personnel.

As a preface to the discussion of observations on the effectiveness of existing programs it should be noted that the criteria used in evaluating the programs differ with the perspective of the responding organization. Evaluations from personnel offices tend to place the emphasis on the effectiveness of the programs in recruiting and retaining scientists and engineers. For example, pre-college programs tend to be lightly regarded by this criteria because they will not provide an immediate supply of new personnel. Fellowship programs are evaluated on the number of degrees earned and the retention of the graduates in defense-related fields. The part-time research assignments tend to be evaluated on the contribution made to the research effort of the organization, and this judgment is influenced by the overhead and indirect charges assessed against these special positions. Developing criteria appropriate for DoD-wide policy decisions will be a part of the study on future needs.

Among the programs that are most effective for recruiting are the Career Intern programs that recruit from campus for an accelerated promotion track and also provide some advanced education as part of the package. Co-op programs, likewise, are rated as very effective, with recruitment rates of 65-70 percent reported in some organizations. At the advanced degree level, the post-doctoral research associateships are very effective in providing a continuing supply of well qualified graduate scientists and engineers for conducting research in DoD laboratories or under university grants and contracts.

The in-house training programs are generally considered important both for providing educational opportunities for employees and as a recruiting tool. However, these in-house training programs are currently limited by statutory restrictions which do not permit payment of costs associated with obtaining a degree. This restriction, coupled with others limiting an employee

to one year of long-term training in ten years service (or even two years with an exception) makes it very difficult to assist employees to pursue advanced degrees in science and engineering. Educational benefits for private industry are not as restrictive, thus making DoD and federal recruiting in general less competitive with the private sector. A change in training regulations, to permit limited exceptions to these rules for career fields where the government is encountering difficulty in recruiting and retaining employees, is proposed in H.R. 2544 as an Administration goal for all federal agencies and may provide some relief for this problem. The long-standing issue of compensation comparability with private industry is still the major determining factor in retention rate of scientists and engineers in government service.

Among the research office programs, the research assistantships supported by research grants to academic faculty are considered the most effective because the student support is coupled with the needed facilities, and the research is performed in an area of interest to DoD. Fellowship programs with a laboratory tie are next most effective in terms of training students in an area of research of interest to DoD and recruiting the students upon completion of their education. The unrestricted fellowships provide the least return to DoD in terms of direct recruitment of scientists and engineers but they attract more capable individuals in a situation where there is a limited supply of qualified candidates and a fellowship with the least restrictions on future employment opportunities is considered the most desireable.

DoD's investment in science and engineering research and related education programs at HBCUs has increased from about $2 million in FY 1981 to approximately $12 million in FY 1989, according to the OSD minority business office. Moreover, efforts are being made to meet the requirements of section 1207 of Public Law 99-661, the 1987 National Defense Authorization Act, which directed DoD to reach a goal of five percent for contract awards to small disadvantaged businesses, HBCUs and MIs. As DoD's support for science and engineering education at the university level is derived from authority to conduct research, the fact that fewer than a third of the 106 HBCUs have graduate programs in science and engineering fields, and only ten offer the Ph.D. degree, circumscribes DoD's relationships with a large number of these institutions. It is clear that a long term effort will be required to build the research capability of HBCUs. This effort must include steps to interest students in science and engineering careers; to provide them with the education needed to gain admission to science and engineering curricula; to build the infrastructure (equipment and facilities) of the science and engineering departments; and to acquaint the faculty with the research and technology needs of the DoD.

Pre-college programs range from short exposure tours, speakers and science fairs to more intense tutoring and summer experience programs. Judged from an education criterion, the most effective are those that influence career decisions for science and engineering, provide the necessary career guidance and a glimpse of the excitement and adventure in a science and engineering career. The high school Apprenticeship Programs provide these elements but tend to be under-publicized and under-funded. Experience programs such as Summer Aid, Stay-in-School, Federal Junior Fellow, Co-op, etc., which provide broad employment opportunities for the high school and undergraduate student, should be refocused to provide these experiences in the science and engineering area. For example, restrictions that discriminate against dependents of federal employees should be removed. In an era when finding enough scientists and engineers is a problem, it is counter-productive to bar participation from a group with a higher than average likelihood of pursuing careers in such fields, particularly with the Federal government. Another observation was that restrictions on payment of travel expenses make it difficult to use co-op programs in recruiting to meet minority employment goals. For example, Puerto Rican university students enrolled in science and engineering fields were interested in participating in co-op programs but could not find the financial resources to travel to and live in the Washington, D.C. area.

Another observation and concern expressed by many of the respondents was that financial support for education and training programs is subject to wide swings depending on the budget pressure. There was nearly unanimous concern that the impending cuts in the Defense budget would result in disproportionate reductions in training and education programs. Another related concern is that enthusiasm for new education initiatives, pursued without the addition of new funds, will eliminate current programs which are judged to be effective. An example of this latter situation was the establishment of the National Defense Science and Engineering Fellowship at the expense of existing research programs which supported research assistantships. There was no net increase in the number of scientists and engineers trained and a proven program was replaced with one which does not couple financial support to the facilities support needed for science and engineering graduate training. The separation of the fellowship support from both a principal investigator working on DoD projects and work experience in DoD laboratories also makes it less effective for recruiting.

PROGRAMS BEING EXPANDED

The statutory direction requiring this report requested DoD to evaluate its science and engineering programs and identify those planned for expansion. It is premature to recommend expansion of programs since, as mentioned previously, a study is in progress to do just that. Several programs were identified, however, which are already in the process of expansion or initial implementation.

The Army has recently placed the Science and Engineering ROTC Co-op program on a permanent basis after a five-year experimental trial. Constraints on the conventional Army ROTC program do not permit selective recruiting of scientists and engineers for ROTC scholarships. This program addresses the need for increased numbers of scientists and engineers by, a) providing scholarship support for tuition, fees, and a subsistence allowance up to $5000 per year; b) providing co-op jobs at Army laboratories for additional financial support; and c) providing for commissioning in the Reserve forces rather than active duty. The program is currently offered at 145 colleges and universities that meet the requirements of a strong science or engineering program, an Army ROTC program on campus and a co-op program in operation. Participants incur an obligation for service in the Army Reserves and an employment obligation at an Army laboratory in the ratio of three years service for each year of tuition support provided. There are currently 216 participants in the program. It is considered to be an effective program in terms of providing and retaining trained scientists and engineers but the demanding requirements make it difficult to recruit candidates.

The Office of Naval Research is implementing an initiative to assist HBCUs in strengthening their science and engineering departments. Of the 106 HBCUs, only one-third offer graduate courses in science, math and engineering and only ten grant Ph.D. degrees in these fields. Thus, a long-term comprehensive program, addressing all levels of the educational system will be required to materially increase the number of science and engineering graduates from these institutions. ONR has recently announced an increase in their current $3.9 million per year program with the award of six new grants for a total of $14 million over a five-year period. The program includes direct support for more than 100 undergraduate scholarships and research associateships, faculty research grants, summer research appointments for students, and programs for visiting scholars. Each of the schools awarded a grant will complement the ONR research program with pre-college programs to stimulate interest in science, math and engineering career fields and to improve the quality of science and math education at the pre-college level.

The Air Force has indicated that its highest priority personnel program is the Palace Knight program scheduled to begin

in January 1990. The program is designed to address the critical problem of maintaining a supply of scientists and engineers at the entry level for advanced degree positions. The Palace Knight program uses OPM direct hire authority to recruit recent college graduates in the engineering disciplines. Other hiring authorities will be used to recruit college graduates majoring in science fields. The new employees are hired at the GS-7 level and report directly to their universities as the first duty station. They pursue advanced job-related training in their career field and usually receive a M.Sc. degree in one to two years as a by-product of the training. They are then assigned to a laboratory or other work position for three years. With satisfactory performance in their work assignments, they can then return to school to pursue additional advanced training which usually leads to a Ph.D. degree as a by-product of the training. A continued service agreement of three years for each year of training must be signed prior to employment. The program is planned for approximately 100 participants per year on a continuing basis.

The National Defense Science and Engineering Graduate (NDSEG) Fellowship program is the most recent graduate research education initiative. The program was authorized by Congress in 1989 to increase the number of students pursuing advanced degrees in science and engineering fields of importance to DoD. The fellowship pays $15,000 per year the first year, $16,000 the second year, and $17,000 the third year as well as full tuition and fees for a period of three years. The program will provide fellowships for approximately 120 fellows a year with a total of 360 in the program after three years. Support for the program is provided by the Service research offices (ARO, ONR, AFOSR) and DARPA. The program is operated by Battelle under contract to the Services. The initial solicitation for fellows was very well received with 4,200 applications for the 126 NDSEG Fellows selected in 1989. Annual funding for the program was $10 million in 1989 with an increase to $11 million anticipated for 1991.

EVALUATION OF SPECIFIC CONCEPTS

The statutory direction requiring this report requested DoD to evaluate four concepts. They are:

1. Summer internships at DoD laboratories for pre-college teachers of science, engineering or other technical disciplines.

DoD has two established teacher intern programs and various DoD laboratories have experimented with such programs from time to time. The most successful format appears to be one which provides the teachers with a broad update on new areas of science and science teaching prior to an eight-week laboratory experience. The teachers appear to benefit from exposure to a research environment and the activities of career scientists and engineers; the

opportunity to participate in a research project; exposure to current topics of interest in science and engineering; and the enhancement of scientific knowledge primarily through the academic component.

As this report shows, DoD brings large numbers of high school, undergraduate and graduate students, post-doctoral scholars and faculty researchers into its laboratories for research experiences during the summer. These programs were built gradually over a long period of time. (See Table III which shows the range of participants in summer research experiences at the Naval Research Laboratory as an example.) DoD favors increasing the participation of pre-college teachers of science and math in those laboratories which can productively absorb larger numbers of summer researchers at various levels of capability. These summer internships for pre-college teachers support the President's and the Governors' national goals for education by providing opportunities for teachers of mathematics and science to expand their scientific knowledge.

The joint DDR&E/ASD(FM&P) study of successful intervention programs cited earlier will evaluate the existing teacher programs now underway and explore possible methods of expanding this idea.

2. An award program for exceptional pre-college teachers in sciences, engineering and other technical disciplines.

The Bush Administration, in recognition of the importance of awards programs for exceptional pre-college teachers, has expanded the existing Presidential Awards for Excellence in Science and Mathematics Teaching program to include elementary as well as secondary teachers. The Administration has proposed, in the Education Excellence Act of 1989, that the Congress create an expanded Presidential Awards for Excellence in Teaching Program to encompass an even greater number of exceptional teachers.

Although DoD does not have the expertise or experience in pre-college education to operate an awards program independently, the Department supports existing awards programs conducted by the National Science Foundation and the Office of Science and Technology Policy and would support similar programs which may be developed in the future.

3. A scholarship program for undergraduates in science or technical education who plan to teach those disciplines at the pre-college level.

Scholarship programs for undergraduates in science and mathematics who plan to teach those disciplines at the pre-college level are excellent means for meeting the critical shortage of well-trained teachers in those fields. A number of Bills pending in the Congress include proposals for such scholarship programs to

be operated by the Department of Education and the National Science Foundation. Although the DoD has neither the expertise nor the authority to develop and administer such scholarship programs, it will support the efforts of these agencies. The DoD will participate in the proposed Federal Coordinating Council on Science, Engineering and Technology (FCCSET) Committee on Education and Human Resources which will address the need to increase the supply of technicians and professional science and engineering personnel for the nation. This committee should serve to strengthen interagency coordination, promote more efficient use of expertise in the agencies, reduce program overlap, identify areas of program need, and make more efficient use of limited federal resources.

4. Expanding the Barry Goldwater Scholarship and Excellence in Education Program.

The Barry Goldwater Scholarship and Excellence in Education program was established by act of Congress (20 U.S.C. 4701-4711) as an independent foundation under the executive branch of the U.S. Government with an endowment of $40 million. The Board of Trustees is composed of two members from the Senate, two members from the House of Representatives, eight members appointed by the President, and the Secretary of Education. The Foundation is currently providing undergraduate scholarships to 137 junior and senior class students majoring in science or math who were chosen from each of the states, the District of Columbia, Puerto Rico and the Trust Territories. The scholarships provide up to $7000 per year for financial support. In the last competition 1,200 nominations for the scholarships were received. There are other provisions in the Act for graduate fellowships and for honoraria to volunteers in various school systems. The Board of Trustees has elected not to activate these latter programs until the undergraduate scholarship program is well established.

The DoD supports the Barry Goldwater Scholarship program as an example of a program that recognizes and rewards meritorious academic achievement in the fields of science and mathematics. The program should contribute to increasing the numbers of scientists and engineers available and is therefore worth expanding, although the impact on DoD recruiting would be less than the science and engineering ROTC programs operated by DoD for this purpose.

Section IV. CONCLUSIONS AND RECOMMENDATIONS

The DoD has substantial experience and resources invested in the training and preparation of personnel for military service. The increasing sophistication and complexity of the weapons systems in use today has forced the Department to train the technicians and managers necessary to effectively maintain and utilize these systems. The development of new systems relies on the science and technology base in the DoD laboratories and the defense industry, and this in turn relies on the new knowledge generated by the university and DoD laboratory research communities. This same basic knowledge is the driving force for national competitiveness, as the discoveries pioneered in Defense research make their way into the commercial market place. Factors which diminish the science and mathematics capabilities of the work force as a whole and reduce the supply of trained scientists and engineers in particular are of vital concern both to the DoD and to the nation.

The DoD has the experience and capabilities to contribute to an improvement in the quality of science and engineering education in the country and to assist in motivating and educating a new generation of scientists and engineers. However, except for those functions relevant to training military personnel to perform their duties, keeping its scientist and engineer work force abreast of current developments, and funding research at academic institutions, the DoD has limited authority to participate in science and engineering education programs that impact the larger community. If the DoD (and other mission agencies) are to participate in the rejuvenation of science and engineering education in the U.S. then they need both the statutory authority to do so and commensurate funding to support the tasks assigned.

The DoD has used the authorities currently available to it in creative ways to recruit and retain scientists and engineers and also to motivate students to pursue careers in science and engineering. Several changes which would make the current system more effective have been identified and will be pursued through appropriate channels:

a) Remove restrictions against supporting costs of obtaining degrees in employee training programs (limited relief proposed in H.R. 2544);

b) Provide competitive compensation for DoD scientists and engineers;

c) Remove restrictions on participation of dependents of Federal personnel in student employment programs; and

d) Review and revise travel regulations pertaining to student employment programs where needed to meet minority employment goals or where critical shortages exist.

Finally, the obvious fragmentation of the education programs when viewed from the broad perspective of this report requires some comment. DoD's license to support science and engineering education programs is derived from multiple authorities which have distinctly different objectives in support of the defense mission, and consequently, are overseen by distinctly different organizations within the Office of the Secretary of Defense (OSD), namely, military education and training, OASD(FM&P/MM&PP); civilian personnel recruitment and training, OASD(FM&P/CPP); and research and development, ODDR&E. Moreover, responsibility for managing these programs is further delegated via comparable organizational structures within the Military Departments and Defense agencies. Within these organizational structures, education, per se, and science and engineering education as a particular disciplinary subset, may not, in many cases, be a primary function of the offices to which it is assigned.

Nonetheless, we have found that the programs are reasonably well coordinated and function effectively as a result of many years of experience. However, with the growing interest in the impact of the educational welfare of the nation as a whole on DoD (such as education of women and minorities, partnerships-in-education, etc.), there is a need for improved coordination between the three major functions.

REFERENCES

1. "Science and Technology Resources in U.S. Industry." (NSF 88-321). National Science Foundation, Washington, D.C., 1988.

2. Defense Manpower Documentation Center data for 1986.

3. "Changing America: The New Face of Science and Engineering," Interim report of the Federal Interagency Task Force on Women, Minorities and the Handicapped in Science and Technology. September 1988. Washington, D.C.

4. "Science & Engineering Indicators - 1987," National Science Board, (NSB 87), Washington, D.C., U. S. Government Printing Office, 1989.

5. "Academic Science/Engineering: Graduate Enrollment and Support, Fall 1987." (NSF 89-315). National Science Foundation, Washington, D.C., 1989.

APPENDIX A

SCIENCE AND ENGINEERING EDUCATION PROGRAMS SUPPORTED BY DoD

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
**EDUCATION LEVEL PRE-COLLEGE LEVEL								
*PURPOSE IMPROVE QUALITY OF SCIENCE TEACHING								
Summer HS Faculty (HSSMF)	A	ARO	84	128	543			For sci/math teachers. 6-10 wks at Army Labs working on research projects.
Natl Sci Resources Center	OSD	NSRC	87	5000	250			Study and Pilot testing of Science Teaching at Elem school level. Jt. with Natl Acad Sci and Smithsonian Inst. 5yr program. Testing in DoDDs system. Estimate 5000 participated in field testing materials.
Subtotal				5128	793			
*PURPOSE EXPERIENCE								
Res & Engr Apprentice (REAP)	A	ARO	80	110	300	44	63	Students work with mentor at local University. Mentor receives part of grant fund.

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
High School Apprentice Science & Eng.	AF	AF Labs	86	103	180			8 wk. program.
Apprentice Prog	N	Labs	81	667	1105	262	192	Jr/Sr. High teachers work at labs for 10 wk period during summer. Supervise students. Teachers have 8 Saturday lectures prior to experience.
High School Apprentice	N	ONR	81	80	180			HS students work in academic research labs with DoD funded faculty.
Student Volunteer Services	N	NRL	87	4	0	3	1	
Gould Science Award	N	NCSC	74	3	0	3	0	Award to top science student in local HS. Offered summer employment.
Gifted & Talented Prog	N	NRL	79	1	3	0	1	Students work in lab during school yr and vacations.
Subtotal				968	1768	312	257	

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
*PURPOSE STIMULATE INTEREST IN SCIENCE								
Jr Sci & Humanities Symp	A	ARO	57	10000	850	4500		43 Regional conferences. 2-3 day meet with student papers, lectures, tours. HS teachers also attend.
Sci & Engr Fair	A	UNITS	59	715	50			350 state and regional fairs, approx. 100,000 students nationally. Army provides awards.
Texas PreFreshman Engr.	DMA	TEXAS	84	1096	37	575	927	
Adopt-A-School	DMA	DMA	89	36	0			Local Jr HS was selected for Tutoring Assistance.
Navy Science Award Program	N	ONR	81	400	200	0	0	Awards are presented at about 400 Science Fairs around the country.
Subtotal				12247	1137	5075	927	
*PURPOSE TARGETED								
Uninitiated Intr Engr (UNITE)	A	ARO	80	686	105	295	391	4 wk program. Academics, computers, communication skills.

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
Minorities in Engr	N	NADC	85	25	3	17	24	Volunteers give lectures, tour of NADC, career counseling.
Technical Mentor Prog	N	NWC	80	24	0	14	6	Serve as volunteers Jr. yr, offerred summer appt. if successful, renewal by yr is possible.
Manicap Outreach	N	NADC	88	0	0	0	0	tours, career counseling with role model. 2-3 groups per yr.
Subtotal				735	108	326	421	
Precollege Subtotal				19078	3806	5713	1605	

**EDUCATION LEVEL UNDERGRADUATE

---

*PURPOSE EXPERIENCE

Summer Aid, Stay in School	DMA	DMA		65		34	18	
Co-op	DMA	DMA		8		1	3	
Junior Fellow	DMA	DMA		0	0	0	0	
Co-op Education Prog	N	NRL	64	119	700	26	22	Students may be hired GS5-7 on completion of BSc
1040 Hr Appointment	N	NRL	78	81	373	20	25	Provides students research experience during summer and breaks.

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
Stay in School	N	NCSC	81	28		20	11	Work 20hr/wk during term, full during summer. Financial need.
Co-op Program	N	NAVSEA HQ	75	20	40			
Co-op Educ Prog	N	NAVPAC Units	72	16	160	2	7	
S&E Summer Employment Prog	N	NADC	50	16	165	9	2	Research experience during summer.
Federal Junior Fellow	N	NADC	84	12		7	5	Summer and break experience in lab.
Summer Aid	N	NESEA	78	5		3	1	
Federal Junior Fellow	N	NRL	74	4	18	4	4	Selection in Sr., yr. in HS, work summers and vacations at lab. non-comp conversion to govt on completion of BSc.
Federal Jr Fellow	N	NCSC	88	2	60	0	2	Summers after HS grad.
Subtotal				376	1516	126	100	
*PURPOSE EXPERIENCE & FELLOWSHIP								
Sci & Engr ROTC Co-op Prog.	A	PERSCOM	84	147	1331	20	33	Pays up to $5000 for tuition, room & Bd. Incur obligation to Labs for service plus duty in Reserves.
Subtotal				147	1331	20	33	

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
***PURPOSE TARGETED**								
HBCU	DMA	DMA	87	0	0	0	0	
HBCU Prog	N	ONR	79	200	6500			21 INST, Addresses S&E Education in Min inst.
HBCU/MI Adopt-a-college	N	NADC	89	11	176	3	11	Combination of co-op, faculty research, research at NADC.
Undergrad Training Prog.	NSA	NSA	88	17	412	5	17	Intend to expand to 50 in 90.
Subtotal				228	7088	8	28	
***PURPOSE TRAINING**								
Prof Development Center	N	NAVFAC	64	231	7520	94	55	Career Intern
New Prof Develop Prog	N	NCSC	89	21		8	2	Career Intern Program
Accelerated Promotion Prog	N	NESA	79	7		1	1	Career Intern
Part-time Educ Prog	N	NADC	78	6	210			
Undergrad Academic Prog	N	NOSC	77	4	62	3	0	20hr/wk for 2 semesters, upper div courses.
Grow Your Own Prog	NSA	NSA	68	206				Targets 5 critical technician skill areas.

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
Computer Oper Assoc. Prog	NSA	NSA	88	52				Targets Community college students in Computer Opns.
Subtotal				527	7792	106	58	
Undergraduate Subtotal				1278	17727	260	219	
**EDUCATION LEVEL UNDERGRADUATE AND GRADUATE								
*PURPOSE EXPERIENCE								
Co-op	AF	AF units		317		47	41	
Co-op Education Prog	N	NADC	60	63	305	7	14	
Summer Hire Prog	N	NRL	77	55	196	15	8	Summer work experience.
Co-op Programs	N	NOARL	77	6	89	5	2	
Co-op Program	NSA	NSA	55	253	2024	57	18	80% of coops become full time empl.
Summer Program	NSA	NSA	76	64				
Subtotal				758	2614	131	83	
*PURPOSE TARGETED								
Jackson St Res & Educ Prog	N	NOARL	85	3	40	2	3	Faculty and students perform research at NOARL.
Subtotal				3	40	2	3	

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
^PURPOSE TRAINING								
Civilian S&E Career Program	AF	AF units	88	40	107			
Long Term Full Time Training	DMA	DMA	72	49	400	11	0	
S&E Training Prog	DNA	DNA		80	90			
Engineer & Acquisition Manage	N	SPAWAR HQ	89	529	700	54	89	
Engr & Sci Development Prog.	N	NAVAIR	62	162				recruit on campus for program participants.
Long Term Training Prog.	N	NWC	51	20	193	5	3	
National Cryptologic School	NSA	NSA	65	17329	180	7153	1825	NCS established by law. Similar to other employee TR programs but with emphasis on cryptology. Part are ∦ of courses taken.
After Hours College Prog	NSA	NSA	65	1500	2600			participants are individual courses taken.
Advanced Study	NSA	NSA	65	507	1100			20 hrs work, 20 hrs academic per week.
NSA Fellowship & Scholarships	NSA	NSA	65	19	47			Includes several resident, non-res, & adv study programs.

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
Directed Fellowship/Scholar	NSA	NSA	65	11	40			on campus outside Baltimore/ DC area. Tuition + Travel + 1/2 per diem after 30 days.
Subtotal				20246	5457	7223	1917	
Undergrad/Grad Subtotal				21007	8111	7356	2003	
			**EDUCATION LEVEL GRADUATE					
*PURPOSE FELLOWSHIP								
URI Fellow	A	ARO	87	150	3013			
Natl Def S&E Grad Fellow	A	ARO	89	31	2358			
Sci & Tech Fellow	A	ARO	85	8	150			Program being replaced by Nat'l Def S&E Grad Fellow.
Lab Grad Fellowship Prog	AF	AFOSR	86	50	1661	6	0	Students spend summers in Labs. Mentor in Lab advises on thesis research.
Res in Aero. Prop. Tech Fel	AF	AF	82	45	908	2	0	Graduate Fel. co-op program: MIT, Purdue, Texas A&M, Princeton, Penn St.-Univ., with Allison, Textron, Garrett, GE, Pratt & Whitney-Industry.

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
National Defense S&E Grad Fel	AF	AFOSR	89	30	2540	9	0	
Adv. Thermionic Research Fel	AF	AF	77	20	465			
Jt. Svcs. Electronics Fellow	AF	AFOSR	89	3	90			Funded by Jt. Svcs. Electronics Committee. Increase to $300K/ yr. by '91.
Natl Def S&E Grad Fellow	DARPA	DARPA	89	26	1718			
ONR Grad Fellow-ship Prog	N	ONR	82	139	4100	43	18	
Natl Def S&E Grad Fellow	N	ONR	89	39	3390	12	5	
Subtotal				541	20393	72	23	
<u>*PURPOSE PERFORM RESEARCH</u>								
Grad Student Research Prog	AF	AF labs	82	102	810			10 wk summer program. Work with summer faculty profs or AF scientist at AF labs.
Research Assistant-ships-Gen'l	All	ONR, ARO AFOSR	46	8235	156500			Estimate numbers from NSF data. $K estimated at 19K ea.
Subtotal				8337	157310	0	0	

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
*PURPOSE TRAINING								
Mission Related Grad Prog	A	Corps of Engrs.	80	26	1713			
Water Resources Planning Assoc	A	Corps of Engrs.	80	12				
Operations Res Syst Anal Fel	A	HQDA	85	8	280	2	1	6 mo. program. Operations Research specialty.
Operations Research Adv Study	A	AMC	89	5	284	1	1	curriculum at 10 approved universities with Operations Research Programs.
Water Resources & Environ Law	A	Corps of Engrs.	80	2	132	0	0	GW Univ Law + 10hr per wk in Off of Chief Counsel, USACE.
Coastal Engr Educ. Program	A	Corps of Engrs.	75	0	0	0	0	Offered at Texas A&M every 3yr. 9mo on campus 3mo at Coastal Engr. Ctr, Vicksburg, MS
WES Grad Institute	A	Waterways Expt Sta	87	0	0	0	0	Courses at Co-op univ.
Palace Acquire	AF	AF	86	49	709	17	20	
Palace Knight	AF	AF	90	0	0	0	0	

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
Full-Time Study Program	DIA	DIA		0	0	0	0	1 yr Program.
After Hours Tuition Support	DIA	DIA		25	5			2 Courses per year local
DCI Exceptional Analyst Prog	DIA	DIA						Sabatical program. May include education.
Tuition Assistance	DNA	DNA	72	300	80	84	24	
Grad Study	DNA	DNA						
NAVSEA Institute	N	NAVSEA HQ	80	425	104			
Calif State Univ on-site	N	NWC	77	201	626	31	15	Arrangement for on-site and TV courses at China Lake which is remote site.
Instructional TV	N	NOSC	84	38	72	8	9	On-site. San Diego St. and Penn St.
Edison Memorial Grad Training	N	NRL	63	31	266	11	4	16 hrs academic/24 hrs work at full salary.
Graduate Academic Progr	N	NOSC	77	30	343	6	4	20 Hr/wk max
Full time Grad Educ	N	NADC	65	21	800	4	0	
Long Term Training	N	NAVSEA HQ	75	10	670			
Adv Graduate Res Program	N	NRL	64	4	315	0	1	Full-time study at full salary.
Select Graduate Program	N	NRL	67	2	85	0	0	Full-time study at 1/2 salary.

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
Long Term Training	N	NOSC	77	0	0	0	0	Full time for 2 semesters. Salary + Tuition.
Subtotal				1164	6479	164	79	
Graduate Subtotal				10042	184182	236	102	
**EDUCATION LEVEL POST-DOCTORAL/FACULTY								
*PURPOSE RESEARCH								
Summer Faculty	A	ARO	83	107	1089	7	33	Univ. Faculty work in Labs for 12 wk period. Salary + travel.
NRC PostDoc	A	LABS	57	94	3008	5	6	1-2 yr appointments
Lab Co-op Res Prog	A	ARO	72	10	160	0	0	Pre-cursor to summer faculty . Prog. 3-6 mo. in Labs. Pay salary + travel.
Summer Faculty Research Prog	AF	Labs	75	150	1700			10 wks
Research Initiation Program	AF	AFOSR		75	1700			Proposals submitted from SFRP programs. $ based on salary. Estimate
NRC PostDoc	AF	Labs	58	32	1024			
University Resident Res Prog	AF	Labs, AFOSR	77	24	1942			1-2 yr assignments.
NRC PostDoc	DNA	DNA		5	136	2	0	

PROGRAM NAME	COMPONENT	IMPLEMENTATION UNIT	START DATE	NUMBER FY 89	($K) FY 89	NUMBER FEMALES	NUMBER MINORITIES	COMMENTS
Summer Faculty Res Prog	N	Labs	79	207	2390	17	35	Research experience at Navy. Labs during 10 wk summer appointment.
NRC PostDoc	N	Labs	57	108	3456			
ONT PostDoc	N	ONR	84	77	2185			
Young Investigator Prog	N	ONR	85	44	2530			Grants of $50K/ 3yrs to new faculty for research in areas of Navy interest.
Subtotal				933	21320	31	74	
*PURPOSE TARGETED								
Women Science Sholars	N	ONR	80	6	174	6	0	Radcliffe College and cooperating schools.
Summer Col Outreach (SCORE)	NSA	NSA	87	7	15	0	7	Targets new faculty at HBCU/MI. Summer appts.
Subtotal				13	189	6	7	
Post-Doctoral/Faculty Subtotal				946	21509	37	81	
Grand Totals				52351	235335	13602	4010	

APPENDIX B

SUPPLEMENTAL INFORMATION ON SCIENCE & ENGINEERING EDUCATION PROGRAMS

	Service	Unit	No.'89	$M'89	No. Fem.	No. Min.
Stay-in-School	A	All	4057	-	-	-
Summer Aid	A	All	1465	-	-	-
Federal Jr. Fellow	A	All	246	-	-	-
Summer Employment	A	All	1406	-	-	-
H.S. Co-op	A	All	329	-	-	-
Summer Faculty	A	All	123	-	-	-
HBCU Faculty	A	All	18	-	-	18
Career Intern (S&E)	A	All	1968	-	418	564
Undergrad/Grad Co-op (S&E)	A	All	805	-	-	-
Co-op (S&E)	AF	All	354	-	-	-
Co-op (S&E)	N	All	840	-	-	-
ROTC (All Scholarships)	A	All	10350	-	-	-
ROTC (All Scholarships)	N	All	6589	-	-	-
ROTC (All Scholarships)	AF	All	4800	-	-	-
ROTC (S&E Scholarships)	All	All	13000	105	-	-

APPENDIX H

Objectives for Intervention Programs

Objectives for Intervention Programs

In several sections of this report, we refer to the disparity among the objectives of the intervention programs encountered during the study. Which kinds of objectives are best for DoD? Why?

Since *all* of the program objectives we reviewed are authorized by the laws of the United States, the answer to the above questions then take on a matter of priority and relative value, not absolute right or wrong. In the quest for increasing the size and quality of the national pool of scientists and engineers, is it better, smarter, or more effective to sponsor or conduct programs with little or no immediate payoff for DoD? Or should DoD support only those research efforts and that graduate study that pay prompt and direct dividends (in the form of research products of graduates) to the sponsoring DoD organization? We have programs in our sample that follow both principles.

The legal authorities cited in Appendix D appear to encourage DoD to sponsor activities with both immediate payoff and with more limited or indirect application to DoD missions. If that interpretation is correct, then we can conclude that DoD programs representing positions all along this spectrum of possible objectives are proper and appropriate. Indeed, the existence within the Department of some 136 programs with highly diverse objectives support such an interpretation.

All of the program managers that we met during the conduct of this study are conscious of the "Mansfield Amendment" originally written in 1970 as part of Public Law 91-441, which requires DoD's research, development, and studies funding to have a potential relationship to military work. Officials responsible for intervention programs that have very general objectives believe that their programs fall within the scope of PL 91-441. Other DoD intervention program managers, particularly those advertising specific, mission-related requirements for the work of their participants, believe that DoD should receive direct and immediate benefit from any sponsored activity.

Do some researchers of genuine merit shun opportunities with direct military pay-back requirements? A number of managers believe that they do. These managers believe that such pay-back requirements attract more than their share of second-class scholars and researchers as program participants. These same managers would point out the importance of making friends for DoD among America's foremost scientists and engineers. If a particular scholar or researcher accepts a DoD research contract or postdoctoral fellowship with no strings attached, the researcher then becomes a viable future candidate for principal investigator status for DoD research contracts that may have more direct pay back. In addition, this argument states that this investigator will ultimately do better work for DoD since he or she is one of the nation's "best and brightest."

We are skeptical of this view. We tend to side with the program managers that always demand a mission-related quid pro quo for the DoD. We believe that the more directly such a requirement is articulated to program applicants, the higher DoD should rate the program. We believe that it is better, smarter, and more effective for DoD to request and receive a direct and prompt dividend for the money it spends. During this project we have evaluated several programs that demand relevant, approved-by-DoD research while simultaneously attracting a number of impressive applicants.

As a result, we reviewed the sample programs during the study from this perspective. We do not seek to avoid responsibility for our position, but simply lay out both sides of this argument while announcing our position to the reader.

REPORT DOCUMENTATION PAGE

Form Approved
OPM No.0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	Oct 95	Final

4. TITLE AND SUBTITLE

DoD Educational Intervention Programs for Scientists and Engineers

5. FUNDING NUMBERS

C MDA903-90-C-0006

PE 0902198D

6. AUTHOR(S)

Dayton S. Pickett, David A. Smith

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Logistics Management Institute
2000 Corporate Ridge
McLean, VA 22102-7805

8. PERFORMING ORGANIZATION REPORT NUMBER

LMI- FP002MR1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Assistant Secretary of Defense (Force Management Policy)
4000 Defense Pentagon Room 3E784
Washington, D.C. 20301-4000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

A: Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

Over the past five decades, several disparate organizations within DoD have established over 130 separate programs that improve the quantity and quality of professional scientists and engineers in the United States. The programs range from pre-college through postdoctoral education and are generally conducted on a decentralized, independent basis. Are they doing well? What attributes accompany the best programs? What can and should be done to improve the programs?

This study selected 32 programs representing all levels of education and major sponsoring organizations. All programs were visited and assessed using a standard rating instrument designed for the project. The resulting analysis produced recommendations for five broad, complementary actions by OSD. The actions were intended to encourage institutional programs to take on the characteristics of the most successful programs and to establish coordination and guidance mechanisms without imposing undue regulation and needless control.

14. SUBJECT TERMS

science education, mathematics education, engineering education, education programs, supply of scientists, supply of engineers, educational pipeline for scientists and engineers, academic ability, American youth, scholarships, fellowships, internships, work-study programs, cooperative education, graduate study, undergraduate study, science fairs, Defense research

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL